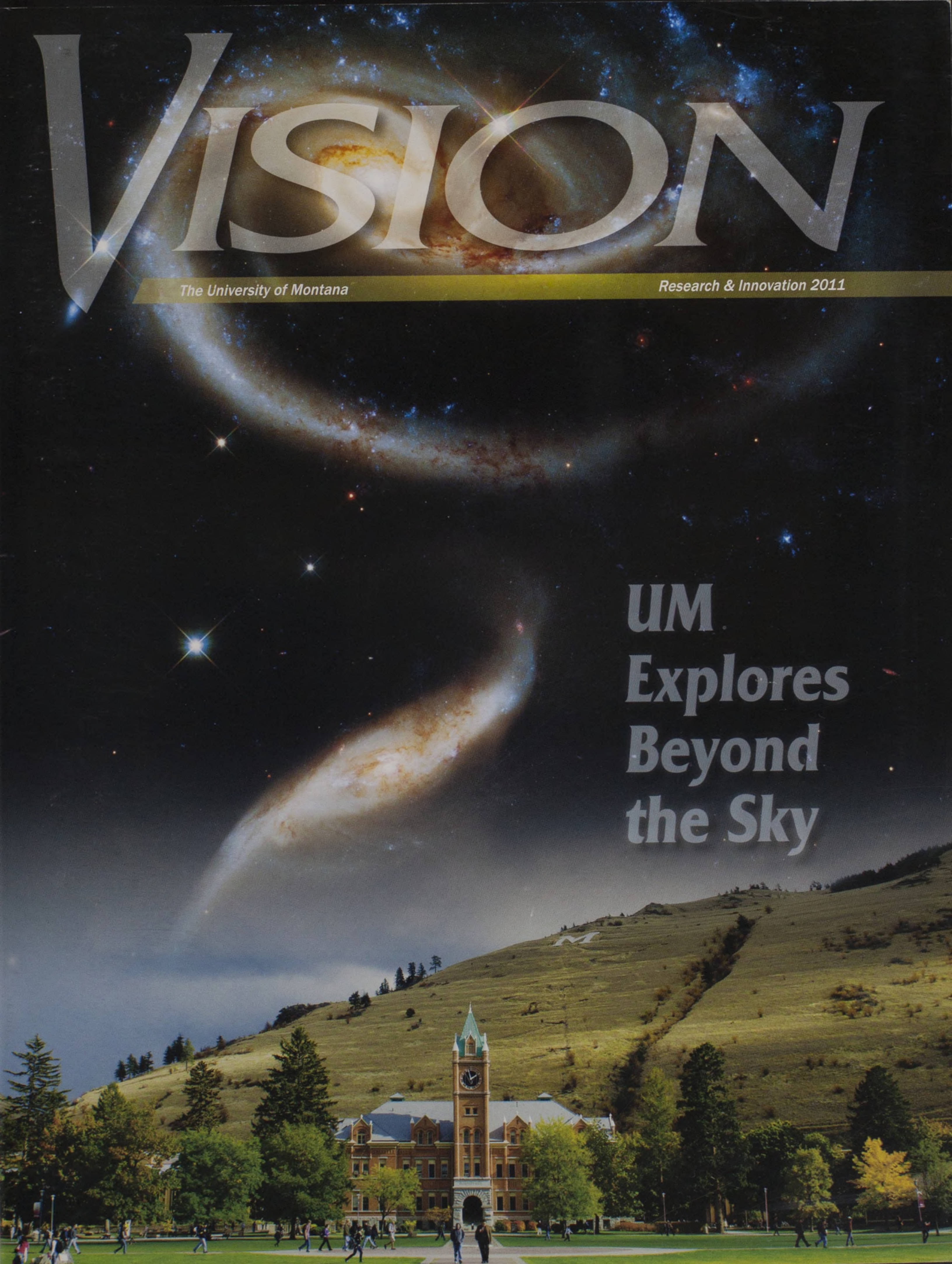
Vision 2011


VISION
The University of Montana
Research & Innovation 2011
UM Explores Beyond the Sky

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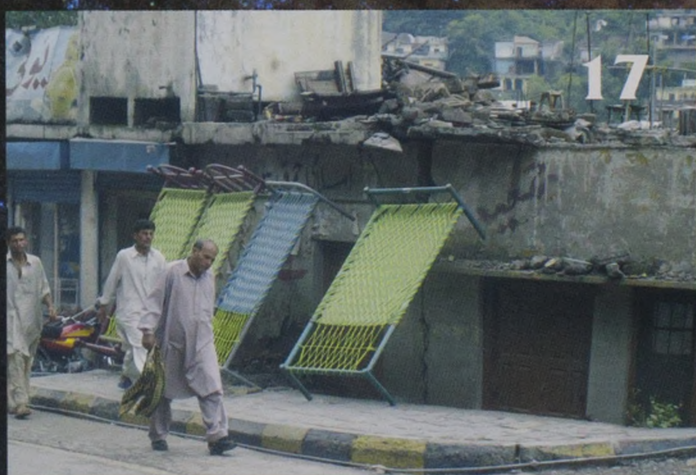

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Cover Illustration:
A Hubble space telescope image of interacting galaxies called Arp 273 blends with a beautiful autumn day at The University of Montana. (Credit: NASA, ESA and the Hubble Heritage Team; Cary Shimek)

Flocculent spiral galaxy NGC 2841
(Credit: NASA, ESA and Hubble Heritage)

Inner Vision

University of Montana scientists have worked with NASA on multiple space probe missions, which have studied everything from Saturn and mapping the edge of the solar system to the composition of the sun.
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Message From The Vice President

This is my final introductory letter for Vision magazine, as I intend to step down from my position as vice president for research and development at the end of the 2011-12 academic year. I look forward to next academic year when I will join my colleagues in chemistry and return to the classroom. I also plan to dust off my fly rod and spend more time in Montana's sparkling streams and mountain valleys that are so dear to me.

As I sit down to write this letter, I have one overriding thought: The research enterprise at The University of Montana is strong and growing stronger.

Daniel Dwyer, UM vice president for research and development, and a new mass spectrometer installed in the Interdisciplinary Science Building

UM researchers expended nearly $64 million in external grants and contracts in fiscal year 2011. I applaud our incredible researchers, who are able to garner such resources in the current competitive climate. It proves we have some of the brightest people in the world working to expand humanity's knowledge right here in western Montana.

Two recent awards deserve special mention. The Montana University System recently received a five-year, $20 million grant to strengthen the state's science and engineering workforce. This award to the Montana National Science Foundation Experimental Program to Stimulate Competitive Research (EPSCoR) required 20 percent in matching funds from the state, and we appreciate Gov. Brian Schweitzer's efforts to find the match. The grant should bring about $10 million to our campus. With the other award, Stephen Sprang and his partners earned a five-year, $9.9 million grant from NSF to fund UM's Center for Biomolecular Structure and Dynamics. The center was one of only four Centers for Biomedical Research Excellence across the nation to earn such funding this year. The UM center will inspire new therapeutic approaches to heart disease, behavioral disorders, viral diseases and drug resistance.

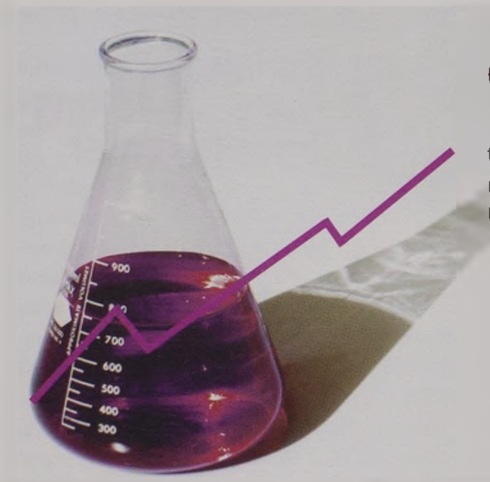
UM now has nearly a dozen core analytical facilities filled with incredible instrumentation such as electron microscopes and flow cytometers. The institution now has stepped up to the plate to support these centers with $300,000 per year, and we have started a fee system so that researchers with federal awards pay to use the equipment. This funding structure will support these vital research facilities for many years to come.

Speaking of new equipment, UM received two major research instrumentation awards from NSF during the past year. Bruce Bowler in chemistry brought a new mass spectrometer to UM, and Julie Baldwin in geosciences purchased a new sophisticated electron microscope for studying nanomaterials.

In addition, UM launched a research development program for the social and behavioral sciences, which we identified as areas we wanted to strengthen. This year about $80,000 will be distributed to social and behavioral scientists on a competitive basis. The money will allow researchers to free up time to focus on their research and prepare major funding proposals.

We have a lot going on, and the stories in this issue of Vision only bolster that argument. The magazine addresses UM studies with space probes, plant communities, helpful relationships with bacteria, earthquakes and more. UM is a productive place for science, and our past efforts have set the foundation for future success.

Daniel J. Dwyer
Vice President for Research and Development
The University of Montana



Campus investigators rake in research dollars

University of Montana scientists expended nearly $64 million in external grants and contracts to support UM's research enterprise in fiscal year 2011. **Daniel Dwyer**, UM vice president for research and development, says that total demonstrates the continued competitiveness of the University's research faculty members.

The top five new award recipients for 2011 were:

- **Terry Weidner**, the Maureen and Mike Mansfield Center, $3.3 million.
- **Andrij Holian**, Center for Environmental Health Sciences, $3.2 million.
- **Charles Thompson**, Department of Biomedical and Pharmaceutical Sciences, $1.8 million.
- **John Kimball**, Flathead Lake Biological Station, $1.65 million.
- **Brent Ruby**, Department of Health and Human Performance, $1.58 million.

Big grant funds new biomolecular structure center

UM recently received a five-year, $9.9 million grant from the National Center for Research Resources, an entity of the National Institutes of Health, to fund research on physiological processes and diseases from the standpoint of atomic structure, chemistry and physics.

The grant will fund research conducted at UM's Center for Biomolecular Structure and Dynamics, which is made up of faculty from the Department of Chemistry and Biochemistry, the Division of Biological Sciences and the Department of Biomedical and Pharmaceutical Sciences. The grant also recognizes the center as an NIH Center of Biomedical Research Excellence (COBRE).

"This award increases the opportunity for research and training at (UM) by providing salaries for junior investigators and their support staff, as well as funds for essential cutting-edge technology," says **Dr. Barbara Alving**, National Center for Research Resources director.

Insights gained from the research will inspire new therapeutic approaches to drug resistance, heart disease, behavioral disorders and viral diseases, says **Stephen Sprang**, UM program director of the NIH COBRE grant.

It will fund the specific research of four UM faculty members:

- **Klara Briknarova** will use advanced spectroscopic methods to understand how viruses employ specialized proteins to invade human cells.
- **Xi Chu** will use quantum mechanical methods to learn how physiologically critical enzymes use metal ions to catalyze reactions.
- **Valeriy Smirnov** will use state-of-the-art biochemical methods to understand the catalytic mechanism of an enzyme that uses iron to convert the common amino acid tryptophan into serotonin, an important neurotransmitter.
- **Erica Woodahl** will use biochemical and spectroscopic methods to understand how certain transporter proteins alter the therapeutic effect of drugs and how this information can be used to improve drug development.

"The most important immediate impact of COBRE funding will be to accelerate the research of four talented young investigators on this campus and to provide resources to help UM recruit first-rate faculty at the forefront of biophysical and biomedical research," Sprang says.

By providing support for common core facilities at UM, COBRE funds also will enhance scientific collaborations with UM's Center for Structural and Functional Neuroscience and the Center for Environmental Health Sciences, both of which also have been awarded funding as COBRE centers.

Director Stephen Sprang stands in part of the space that will house the new center in UM's Interdisciplinary Science Building.

Major award will aid children in Indian Country

National Native Children's Trauma Center

The federal Administration for Children and Families recently announced that the National Native Children's Trauma Center at UM and its partners have won a $3.2 million grant to apply cutting-edge research to the problems of child abuse and neglect in Indian Country. The award is one of five such grants in the nation.

The work will benefit at least three reservations in Montana during the next three years, bring pilot programs to three more reservations elsewhere in the nation and ultimately serve as a model for similar work throughout Indian Country.

"This award will allow us to forge key partnerships that will fundamentally change how agencies and institutions serve the deserving children in these communities," says **James Caringi**, co-principal investigator and professor at UM's School of Social Work. "Research nationwide has assembled vast knowledge about identifying and treating childhood trauma resulting from abuse and neglect. This grant allows us to effectively deploy this knowledge in communities that need it."

The center at UM has been a pivotal player in the National Child Traumatic Stress Network for eight years, helping compile evidence directed at the effects of abuse and neglect on children. Until now, the center's work has been concentrated in schools, delivering evidence-based interventions for problems rooted in trauma such as alcohol and drug abuse, delinquency and teen suicide. The new grant, however, will allow that focus to expand by moving beyond schools to involve child and protective service workers, parents, extended families and foster parents.

NNCTC will provide these key players with background training in the latest epidemiological and psychological findings that indicate child abuse and neglect lie at the root of the nation's most important social problems.

"One landmark study, for instance, demonstrated that the effects of child maltreatment often last well into adulthood and are a direct cause of major health problems like obesity, heart disease and lung disease," says **Rick van den Pol**, the project's other co-principal investigator and director of UM's Institute for Educational Research and Service. "We must intervene because abused children, on average, die 20 years earlier than the rest of us, according to one study."

National research, however, also has developed a proven list of low-cost and effective interventions that allow recovery and resilience. NNCTC will train in these methods and ensure systems of delivery are in place and functioning during the grant's first three years.

Finally, the work will train child welfare workers in recognizing and treating secondary traumatic stress, the burnout and compassion fatigue that can plague caregivers who face these problems daily.

All of this work will rest on a series of key partnerships and collaborations, including with the federal Bureau of Indian Affairs, state welfare and education agencies and tribal government on reservations that agree to participate. For this major project, NNCTC also has partnered with the Butler Institute for Children and Families at the University of Denver's School of Social Work and has assembled an advisory council of national experts to support implementation and oversight of the project.

Cory Beatty, the research lab manager for Mike DeGrandpre, lowers a sensor destined to be used beneath Arctic ice into a test tank.

Sensors beneath Arctic ice to study climate change

UM chemistry Professor **Mike DeGrandpre** and his partners have been awarded a $926,000 National Science Foundation grant, which will fund placement of carbon dioxide and pH sensors in the perennially ice-covered portion of the Arctic Ocean.

The sensors will be placed on ice-tethered profilers to be deployed by DeGrandpre collaborators **John Toole** and **Rick Krishfield** of the Woods Hole Oceanographic Institution. Ten CO_2 and pH sensors in six locations will be placed just below the ice by drilling holes through the ice.

Data will be transmitted back to Woods Hole in Massachusetts via satellite, where it can be viewed as the sensors drift with the Arctic ice pack. More information on the ITP instruments is online at http://www.whoi.edu/itp.

The ITPs will be part of a larger Arctic Observing Network, in which sensors of all kinds are used to document changes in the Arctic.

"With global warming we are seeing less summer sea ice, and the sea surface is warming and freshening," DeGrandpre says. "This changing physical environment is altering the carbon cycle in the Arctic Ocean."

He says it's unknown whether carbon sources and sinks will change and whether these changes will lead to increased CO_2 accumulation in the atmosphere, causing further warming.

The sensors also will measure the penetration of human-produced CO_2 in the Arctic Ocean, which leads to acidification with potentially fatal consequences for many organisms. The sensors will document changes in the CO_2 cycling and ocean acidification in the Arctic during the next three to four years.

The CO_2 and pH sensors will be customized for deployment in the Arctic by Missoula's Sunburst Sensors, a company co-owned by DeGrandpre and spawned by his UM research. The research project also will support development of an exhibit highlighting climate change effects on the oceans at spectrUM Discovery Area, an interactive science center for children in UM's Skaggs Building.

USDA awards highest honor to UM wildlife professor

UM wildlife biology Professor **Dave Naugle** recently received a 2011 Secretary's Honor Award from the U.S. Department of Agriculture for his work on the agency's major sage grouse conservation initiative.

USDA Secretary **Tom Vilsack** presented the annual award – the department's most prestigious – to Naugle, his colleague **Tim Griffiths** and their 33-member team at a ceremony held Sept. 14 in Washington, D.C.

As a USDA science adviser for the agency's Natural Resources Conservation Service, Naugle helped develop and implement its Sage Grouse Initiative over the past year and a half.

"It's exciting to watch Dave help the USDA use science to guide farm bill conservation that mutually benefits ranchers and wildlife in Western sagebrush grasslands," says **Dan Pletscher**, UM Wildlife Biology Program director.

Many factors in recent years, including subdivision and oil and gas development, have led to a decline in the sage grouse population so drastic the bird qualifies for listing as an endangered species. The initiative Naugle helped spearhead aims to conserve core breeding grounds for the highest density of sage grouse while simultaneously helping rural, private landowners make a living – a win-win strategy for agriculture and wildlife, according to Naugle. The initiative targets priority areas for conservation within 186 million acres across 11 Western states with funding from existing farm bill resources.

"The key to success is NRCS's shared vision of achieving world-class wildlife conservation through sustainable ranching," Naugle says. "Helping Western ranchers maintain large and intact grazing lands is the best way I know to maintain our wildlife legacy for future generations."

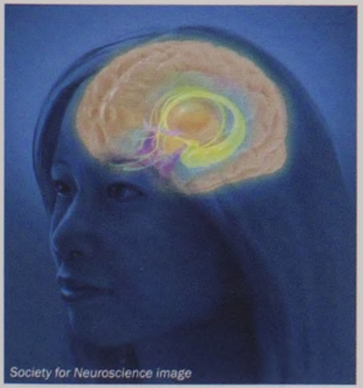
U.S. Agriculture Secretary Tom Vilsack (far left) recognizes UM researcher Dave Naugle (second from right) and National Sage Grouse Initiative coordinator Tim Griffins on Sept. 14 in Washington, D.C.

Funding boosts Big Sky Brain Project for kids

The Big Sky Brain Project, a collaboration between UM's Center for Structural and Functional Neuroscience and spectrUM Discovery Area, recently received a five-year, $1.3 million grant from the National Institutes of Health.

The grant, awarded by the NIH's National Institute on Drug Abuse, will fund a neuroscience learning center called the Brainzone that will feature four hands-on exhibits, a computer lab and a working laboratory aimed at increasing science literacy and interest among K-12 students.

UM will work with the Exploratorium in San Francisco to develop the Brainzone, which will be housed in a future spectrUM location off campus set to open in the fall of 2013. The Brainzone also will be incorporated into spectrUM's mobile science center that travels to schools across Montana, including many in rural and tribal regions.



Society for Neuroscience image

Michael Kavanaugh, director of the Center for Structural and Functional Neuroscience, worked with **Holly Truitt**, spectrUM director, to secure the grant. Kavanaugh says the project is a result of a long-term partnership between his center and spectrUM. The two also are collaborating with other local organizations, including Missoula County Public Schools and Community Medical Center, to bring the Brainzone learning experience to thousands of K-12 students in Montana and around the country.

"One of the unique goals of the project is to expose kids to 'real life' neuroscience research and teach about career opportunities in the fields of science, technology and medicine," Kavanaugh says. "So in addition to the world-class exhibits, we will host a working laboratory with the involvement of UM faculty, including neuroscientist **Sarah Certel** and clinical neurologist **Tom Swanson**."

Campus earns funding to study biomass

Two new grants place UM on the forefront of efforts to use forest biomass to help replace fossil fuels.

First, three College of Forestry and Conservation professors were awarded a $1.1 million USDA grant as part of a research team investigating how to turn forest biomass into an alternative energy feedstock.

The project, part of the U.S. Forest Service's Biomass Research and Development Initiative, will involve faculty members **Woodam Chung**, **Christopher Keyes** and **Tyron Venn**. Each will work on a component of the project over the next four years.

"This research will really help energy providers and the public make important decisions about how and where to efficiently use biomass as an alternative to fossil fuels," Keyes says.

Chung develops spatial models to show where biomass feedstock is located, the various land management objectives across ownerships and the best transportation network for getting the feedstock to a processing facility. Keyes will conduct a long-term study on the effect of biomass harvest for overall forest productivity. Venn studies the economics of deploying woody gasification technology at sawmills to produce biofuels and bioproducts.

With the other grant, UM's Bureau of Business and Economic Research will receive $500,000 during the next five years to conduct logging-use studies in the Pacific Northwest.

The project is part of a $40 million grant awarded to the Northwest Advanced Renewables Alliance, a group trying to make wood-based jet fuel and petrochemical substitutes economically viable. Headquartered at Washington State University in Pullman, NARA includes a broad consortium of scientists from universities, government laboratories and private industry.

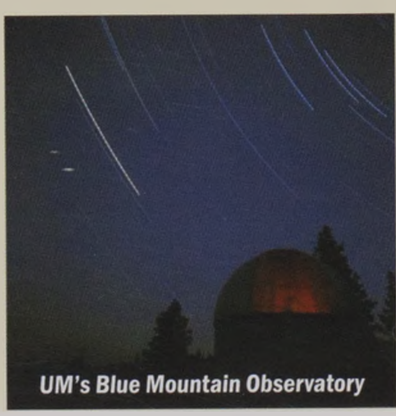
"I am honored and excited to be invited to participate in this project," says the BBER's **Todd Morgan**. "We will learn a great deal about the regional viability and sustainability of a woody-biomass fuel industry, and I'm glad UM will play a role in gathering and sharing that knowledge."

UM science department celebrates 100 years

UM's Department of Physics and Astronomy celebrated its 100th anniversary with a research conference, reception and observing night on Sept. 30.

"It is an honor to think that we are carrying on a tradition of teaching physics and astronomy at UM that has been ongoing for 100 years," says **Andrew Ware**, department chair. "We were lucky to have a distinguished group of alumni return to UM to tell us about their current work."

The department honored the milestone with an alumni research conference that included **Hilary Martens**, California Institute of Technology graduate student; **David Westerly**, University of Colorado-Denver assistant professor; **Brent Buffington**, NASA Jet Propulsion Laboratory mission specialist; and **Ahmed Diallo**, Princeton Plasma Physics Laboratory scientist. That was followed by a reception and observing night at the Blue Mountain Observatory.



UM's Blue Mountain Observatory

Technology magazine honors UM for innovation

UM recently joined the likes of Duke, Penn State, Purdue and Pepperdine as winners of a 2011 Campus Technology Innovators award. UM's Academic Planner, a homegrown Web application that helps students plot short-term course schedules and develop long-term academic strategies, was deemed one of the 10 best innovations in higher education out of 393 nominees.

The awards are presented annually by Campus Technology magazine, a monthly publication focused on the use of technology in higher education.

Academic Planner provides advanced search tools to help students sift through hundreds of University course offerings and create primary and alternative course schedules. **Jon Adams**, lead programmer on the project, says the most popular feature of Academic Planner is an interactive visual calendar. Students can simply mouse over search results and see how each course would fit into their schedule.

The first version of Academic Planner was released in 2009. Since then, 12,600 people have logged in and used the tool.

While Academic Planner was developed by UM's Information Technology office, Interim Chief Information Officer **Loey Knapp** credits more than two dozen people serving on advisory groups for guiding the development and evolution of the tool. The Office for Student Success also played a key role in the development and adoption of Academic Planner, Knapp says.

"They did the project an enormous favor by seeing the value in it and adopting it," she says.

UM Office for Student Success Director **Sharon O'Hare** says that an early prototype of Academic Planner convinced her that the tool had great potential.

"It allows students to develop a specific pathway for four-year graduation," she says. "And it gives them the ability to play with 'what-if' scenarios and what it would mean to take different paths."

Scientist discovers ancient coral fossils in Nevada

A team of researchers led by UM geosciences Professor **George Stanley Jr.** found fossil corals in central Nevada representing the oldest occurrences in North America of ancestors of modern reef-building species.

The team found annual bands in the coral's skeleton, allowing them to accurately measure growth rate and to make comparisons with living reef-building species. The comparisons revealed nearly identical results.

The discovery provides the most unequivocal evidence to date for the presence of photosymbiosis among the earliest corals some 230 million years ago and long before coral reefs with modern corals evolved, Stanley says.

"We live in a symbiotic world," he says. "Photosymbiosis is a process whereby microorganisms live inside and benefit a host animal. This process is best exemplified in corals, the master builders of reefs, whose fast growth rates and improved nutrition are attributed to symbiotic algae.

"In fact," he says, "we wouldn't have modern or ancient reefs if it weren't for photosymbiosis, and photosynthectic algae and corals account for the success of reefs, which today are key players in global climate change."

Stanley says it may well be that the symbiotic algae, not the corals, are the real masters of the reef, because discovery of photosymbiosis among ancient corals in the Nevada site pushes the origin of this important relationship to the Middle Triassic period, about 20 million years earlier than previously thought.

The research, which was published in GeoScience World's journal Palaios, was selected earlier this year to be featured in BioOne, a global, free access site that brings together scientific societies, publishers and libraries to provide access to critical, peer-reviewed research in the biological, ecological and environmental sciences.

Fossilized ancestors of modern reef-building corals found in Nevada

Research sheds light on modern human origins

An international team that includes UM researcher **Jeffrey Good** studied DNA from a 30,000-year-old finger bone found in 2008 in the Denisova Cave in southern Siberia, Russia. The scientists discovered previously unknown connections that occurred among the ancient ancestors of modern human populations.

The team, led by the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, sequenced the nuclear genome of the bone that came from a female of a group of hominins – a term used to refer to humans and their recent ancestors – in Asia who shared an ancient origin with Neanderthals but had a distinct history. The researchers call this group of hominins the Denisovans and published a paper about their findings in Nature.

Some members of this same team, including Good, sequenced the genome of the Neanderthals and published their results in Science. This earlier work indicated that Neanderthals exchanged genes with the ancestors of present-day Europeans and Asians. In contrast, the Denisovans did not contribute genes to all present-day Eurasians but do show genetic evidence of interbreeding with the ancestors of Melanesians.

Good, an assistant professor in UM's Division of Biological Sciences, says the research shows the genetic interactions of our ancestors may have been much more complex than previous scientific studies have shown.

"These two studies have transformed our view of human population history," he says. "In the span of one year, the study of ancient DNA has allowed us to identify a previously unknown and potentially widespread group of extinct humans and to determine that there were likely multiple instances of interbreeding between ancient hominin groups living in Europe and Asia and the ancestors of present-day Eurasians.

"Our results suggest that 2 to 3 percent of the genomes of all present-day Eurasians derive from Neanderthals and that an additional 4 to 6 percent of genetic material in present-day Melanesians comes from Denisovans," Good says.

The sequencing of genomes from the extinct Neanderthals and Denisovans are major technological feats made possible by recent advances in DNA sequencing and years of research on the study of ancient DNA, Good says.

"It is really exciting to think about what we might find next," he says. "There certainly is the potential for many more surprises in the coming years as researchers sequence more genomes from the fossil remains of other archaic hominins."

Study challenges assumed climate change effect

UM researchers, with colleagues from the University of Idaho and the University of California, Davis, have completed a study that challenges a widely held assumption that vegetation will move uphill in response to climatic warming.

The results of the study were published in an article titled "Changes in Climatic Water Balance Drive Downhill Shifts in Plant Species' Optimum Elevations" in Science. They are based on two unique datasets of vegetation surveys collected across the mountain ranges of California — the first in the 1930s and the second in the 2000s.

"These data sets provide us with an unprecedented view of the large-scale distributional changes that have occurred for vascular plants in the past 75 years in California," says Assistant Professor **Solomon Dobrowski** of UM's Department of Forest Management.

The study is the first to report widespread downhill shifts in elevations of plant species because of climate change. Researchers who participated in the study with Dobrowski are UM graduate student **Shawn Crimmins**, the lead author, and UM research analyst **Alison Mynsberge**; UI Department of Geography Assistant Professor **John Abatzoglou**; and UC-Davis Center for Spatial Technologies and Remote Sensing Project Scientist **Jonathan Greenberg**.

"It is widely believed that as global temperatures increase, species will shift their distributions uphill or away from equatorial latitudes in order to take advantage of cooler temperatures," Dobrowski says. "There is evidence for this for some species, but the pattern is not universal. The assumption that temperature is the principal factor defining species' distributions ignores the fact that many species, including plants, are constrained by energy and water availability."

The new research shows that plant species' optimum elevations in California have moved downhill by about 80 meters (about 262 feet) between the 1930s and 2000s, despite widespread and substantive increases in temperature during the 20th century.

"We demonstrate that plants within our study region are tracking changes in climatic water balance — the balance between the amount of water that is lost to evaporation and the amount of water that is available from precipitation — as opposed to changes in temperature," Dobrowski says.

Increases in precipitation in California during the 20th century have outpaced increases in evaporative demand, and this has led to increased water availability across the northern half of the state. Consequently, Dobrowski says, plants are able to maintain adequate water supplies at lower elevations than they were previously capable of, and this has led to downhill shifts in their distributions.

"Forecasts of species response to future climate change are alarming in that they predict widespread extinction and range-shifts for hundreds of plant and animal species," he says. "Much of this research assumes temperature is the dominant driver of species distributions.

"Our study demonstrates that in some cases actual elevation shifts under warming conditions may be counter to widely held expectations but can be mechanistically explained by accounting for coupled climatic constraints on species distributions."

The findings have global implications, given that regional increases in climatic water balance have been identified elsewhere in the northern hemisphere.

"Many locations north of the 45-degree latitude have experienced increased precipitation over the past century," Dobrowski says, "and global climate models generally predict these locations to become wetter over the next century."

Solomon Dobrowski in the field

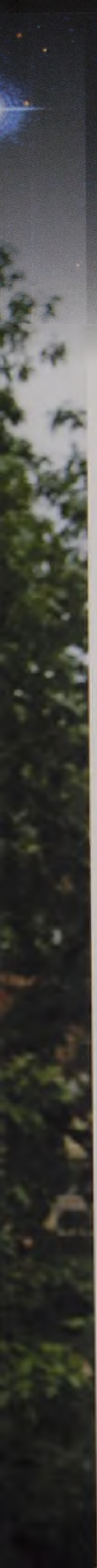
UM's Window on Space

Scientist Dan Reisenfeld has involved UM in multiple NASA space probe missions, which have studied everything from Saturn and mapping the edge of the solar system to the composition of the sun.

Researchers help NASA reveal secrets of the solar system

By Cary Shimek

NASA image of Genesis probe



It was early afternoon in autumn semester 2009 when Dan Reisenfeld jumped up before a class he was teaching at The University of Montana and exclaimed, "There's nitrogen coming off of Rhea!"

The 10 students taking Quantum Mechanics stared at him slack-jawed. You could have heard crickets.

"They gave me a look like, 'What have you been smoking?'" says the assistant professor in UM's Department of Physics and Astronomy. "They were rather bemused by my excitement, but then they wound up asking lots of questions."

For those who aren't astronomy buffs, Rhea is the second-largest of 62 known moons circling Saturn. NASA has an unmanned space probe called Cassini orbiting Saturn, studying wonders such as the intricate system of ice-particle rings and smog-shrouded Titan, the only moon known to have a dense atmosphere. Cassini, and the Huygens probe it sent to Titan's surface, revealed vast methane lakes and wind-sculpted hydrocarbon sand dunes hidden beneath the clouds.

Cassini also detected polar water geysers venting off the Saturnian moon Enceladus back in 2006. Reisenfeld was part of the team that made that discovery, as his research group helps analyze the raw data streamed to Earth from Cassini.

"A lot of these moons circling high-gravity planets like Jupiter and Saturn get their innards churned by tidal forces," he says. "This churning kind of grinds them up inside, generating heat and giving rise to geysers, volcanoes and such."

So back in 2009, while staring at the computer monitor in his campus office to analyze data sent from Saturn, Reisenfeld suddenly made a realization that sent chills cascading through his body. The Cassini data revealed a large nitrogen source emitted from Rhea.

Why does the moon have a nitrogen source? Why is it nitrogen and not water like Enceladus? Why was it so different?

Scientists still don't know the answers. Reisenfeld's discovery had just revealed a new set of mysteries to explore. But at that time he knew just one thing: He couldn't wait to tell his students.

Reisenfeld first visited Yellowstone National Park with his parents when he was 11 months old, and much of his life thereafter was spent trying to return to the West. He grew up loving science and watching "Star Trek" in Cincinnati, and he went on to study physics at Yale and astronomy at Harvard. He considered attending graduate school in Boulder, Colo., but noticed most of the professors there were from places such as Stanford, Berkeley or Harvard. He realized he needed similar credentials to choose where he would work, so he deferred his westward momentum to study back East.

His initial move west came in 1998, when the astrophysicist landed a postdoctoral and then a staff scientist position at Los Alamos National Laboratory in New Mexico, a hotbed for NASA science missions and spacecraft design. He became involved with numerous space probe projects and found time to meet and marry Maureen, a hydrologist. Reisenfeld loved his job, but he also missed teaching, which he had done at Harvard and the University of New Mexico. So in 2004 he accepted a faculty position at UM in Missoula, where he teaches undergraduate classes such as Galaxies and Cosmology, Introductory Physics and Modern Physics.

Maureen, in turn, took the lead on starting an orchard near Stevensville when not working half-time as an engineering consultant. The couple now has 420 cherry, plum, pear, apricot and apple trees that produce fresh fruit for local restaurants and schools. They also have a bright 6-year-old son, Joshua Orion Reisenfeld.

"My wife gives the marching orders with the orchard, but, yeah, I'm a fruit farmer on the side," he says the day he was interviewed for this story. "I got up at 5 a.m. this morning and started plowing."

Reisenfeld, now 44, was followed to UM by research assistant professor Paul Janzen, 40, a Canadian with an eerily similar career path, as he also studied at Harvard as a graduate student before working in Los Alamos. Janzen, however, is more of a dedicated laboratory researcher and doesn't teach classes. Together he and Reisenfeld have used their connections to involve UM in multiple NASA space probe missions that have resulted in startling discoveries.

"They call us Los Alamos-north now," Reisenfeld chuckles. "But we've published enough papers and have a good enough track record to forge our own reputation here at UM."

In fact, Reisenfeld, Janzen and Los Alamos colleague Herb Funsten recently landed a three-year $800,000 grant to design a new mass spectrometer for future NASA space missions. Funding was provided by NASA's Planetary Instrument Definition & Development Program. They call the device they are designing SITOF-MS for Spatially Isochronous Time-of-Flight Mass Spectrometer.

Mass spectrometers are devices that measure the atomic masses or molecular mass present in a given sample. A mass spec on the Cassini spacecraft detected the water erupting from Enceladus and the nitrogen coming off Rhea.

Reisenfeld said mass spectrometers such as the one they will design take in a gas and ionize the sample. Electric fields then are used on the ionized particles to determine their mass. As an example, hydrogen has an atomic mass of one, and helium is four. However, most previous mass specs have trouble differentiating certain atomic signatures. Common diatomic nitrogen and carbon monoxide, for instance, both have an atomic mass of 28.

Mass specs exist that can tell the difference between N_2 and CO, but they are large and consume a lot of power, which isn't an option for many space missions. Reisenfeld says one on the Rosetta space probe, now en route to a comet, can tell the difference, but that device is costly and about 4 feet long.

"The mass spectrometer we are designing will be much smaller — about the size of a 12-pack," he says. "It will need much fewer resources in terms of power requirements and mass. Basically we are using new technologies to solve the same problem, but in a more cost-effective way."

Reisenfeld says the trick to their new mass spectrometer technique is that it will do the job in two stages. First it will measure the mass of the molecules, and then it will break up the molecules into their constituents and measure the masses of the pieces. CO is made up of carbon (mass 12) and oxygen (mass 16). So if the device first detects a mass-28 molecule and then detects one carbon and one oxygen atom, you have carbon monoxide. If you just detect nitrogen atoms (mass 14), you have N_2.

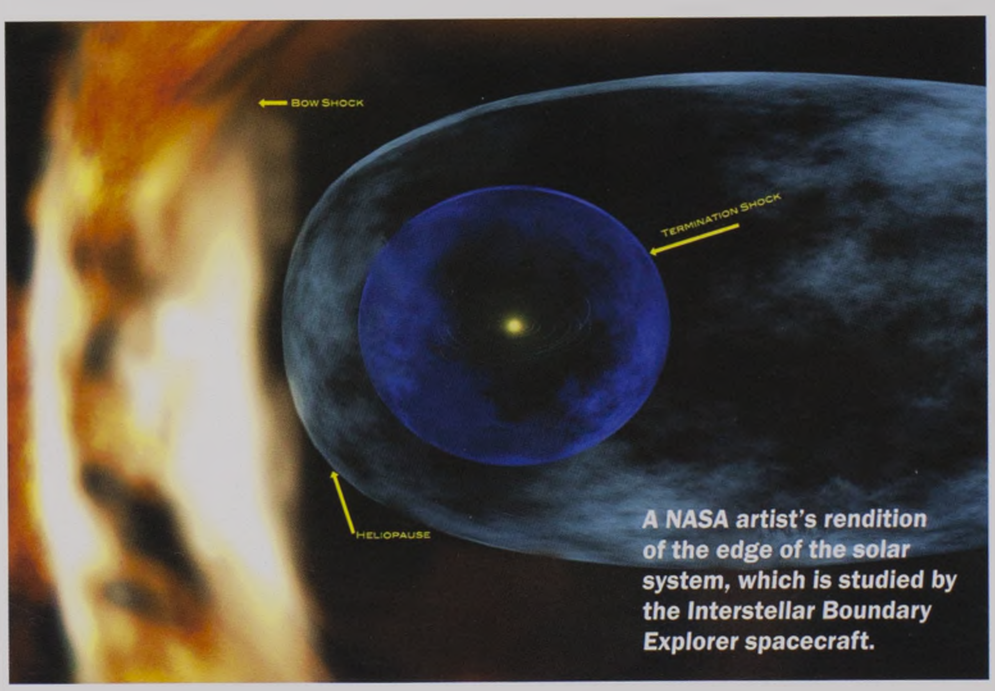
He says NASA doesn't have a specific mission in mind for their device yet. Instead the space agency wants them to work in the laboratory to create a prototype that will be spacecraft-ready soon.

"It's hard to go from an idea to something you want on a spacecraft in one step," Reisenfeld says. "You don't want to risk the idea not working. So the idea is to risk $800,000 in advance development instead of putting a $100 million mission at risk."

He says their mass spectrometer will "sniff" samples in low-density gas environments, such as the Earth's moon, Mars or Europa (a moon of Jupiter that likely hides a water ocean beneath its icy surface). The device should work well on orbiting spacecraft, but it could be used on a lander as well.

Reisenfeld says SITOF-MS will be engineered at Los Alamos, but the scientific functionality of the instrument will be tested in UM's Space Science Lab, located in the basement of the Clapp Building.

During testing the mass spec will be placed within an airless calibration chamber. An ion source will shoot an ion beam into the chamber at the mass spec. Reisenfeld, Janzen and student assistants will know the mass, energy and



A NASA artist's rendition of the edge of the solar system, which is studied by the Interstellar Boundary Explorer spacecraft.

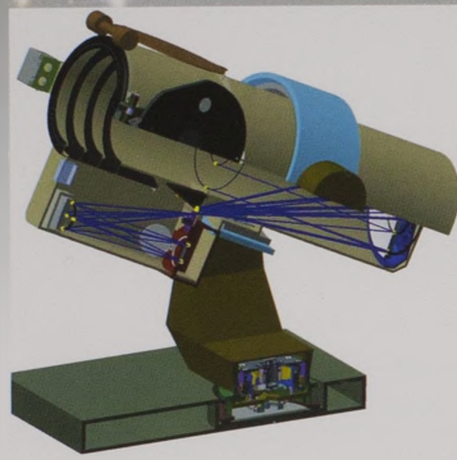
charge state of the particles entering the chamber.

"So our device had better be seeing the same thing we are putting in," he says. "Otherwise we'll know we have some tweaks and work to be done."

Reisenfeld has worked on many NASA missions during his career. Besides Cassini's mission to Saturn, he helped with Ulysses, a spacecraft that studied the solar wind coming from the sun, and Deep Space 1, a probe that did a flyby of a comet in 2001.

He helped build the solar wind concentrator on Genesis, a probe that gathered charged solar wind particles during a three-year journey in space to determine the composition of the sun with unprecedented precision. Genesis was designed to return the samples safely back to Earth, but sadly it crashed in the Utah desert when a parachute failed to open in September 2004. The hard landing made a mess of the Genesis sample collectors, but the probe's science team was able to salvage information from the wreckage and last summer published its results in an article that made the cover of Science.

The Genesis samples suggest the sun and its inner planets may have formed



An illustration of the instrument UM space scientists hope to mount on the International Space Station

differently than scientists previously thought. The data revealed slight differences in the types of oxygen and nitrogen present on the sun and planets. Although the differences are minimal, the implications could help determine how our solar system evolved. Reisenfeld has a grant to continue analysis of the Genesis data.

While Reisenfeld and Janzen have had minor roles on some missions, they are key players for NASA's Interstellar Boundary Explorer spacecraft, or IBEX, which was launched in 2008 to map the edge of the solar system. In 2009 the IBEX science team announced it had detected a vast ribbon of energized particles surrounding the entire solar system.

Reisenfeld says the IBEX mission gave him one of the chief "Eureka!" moments of his career. While studying data in his UM office, he was able to determine that there is a one-to-one correlation between the solar wind pressure coming off the sun and the energetic neutral atoms bouncing back toward IBEX from the edge of the solar system.

"So if the solar wind pressure doubles, the ENA pressure doubles," he says. "It's a perfect correlation. I got cold chills when I was looking at the graphs and saw this, and I was like 'Paul (Janzen), can you come up here for a minute? Is this telling me what I think it's telling me?'

"It's cool because it means we *understand* something better."

Reisenfeld has just submitted a paper to The Astrophysical Journal about how the distributed ENA signal coming back from the heliosheath, a region surrounding the entire solar system, changes over time.

Applying for NASA funding is not for cowards or people who lack perseverance. IBEX has made some amazing discoveries, but Reisenfeld says the probe was submitted for NASA funding three times before it was selected. This is not unusual. His research team also had to submit the mass spectrometer design project three times before NASA agreed to fund it. Reisenfeld says he and his colleagues spend a lot of time submitting proposals and updating ideas that are rejected.

The latest project he wants funded is the Coronal Physics Investigator. This new mission would investigate the mechanisms that heat the sun's corona and release the magnetic energy that accelerate solar wind particles. The corona, which extends 10 million kilometers into space from the sun's surface, is a mystery to scientists because it reaches temperatures of more than 1 million degrees Kelvin, and the surface of

Research Assistant Professor Paul Janzen works on an ion source in UM's Space Science Laboratory, located in the basement of the Clapp Building.

the sun — while still scorching — is only 5,000 K. Scientists don't fully understand how this is possible.

"We know the sun's magnetic field has something to do with it," Reisenfeld says, "but how that massive magnetic field releases the energy is a big mystery."

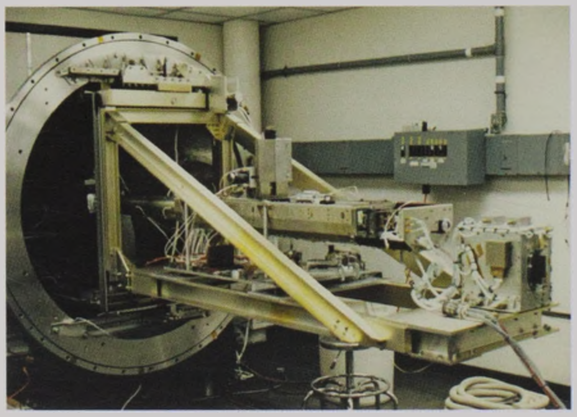
The coronal investigator resembles a small telescope and would be mounted on the International Space Station. The instrument looks at the flaring corona surrounding the sun while discarding light from the sun's disk, creating what's called a coronagraph. The light from the corona goes into an optical spectrometer, which can reveal what's in the corona, the charge state, the density and the velocity.

When Reisenfeld was a Harvard graduate student, his and Janzen's adviser was John Kohl, the principal investigator for an instrument called a coronagraph on the Solar and Heliospheric Observatory spacecraft. SOHO was a big mission in the '90s to study the sun. Reisenfeld says the coronal investigator would have an upgraded version of Kohl's SOHO coronagraph.

"This is the first time I've pitched a mission as the lead author," he says, patting the 100-page proposal sitting on his desk. "This was painful. It took me a week of all-nighters to get this written."

Reisenfeld says Kohl is still the PI for the coronal investigator, and the UM researcher's official title on the project is program scientist. He says Kohl has tried to upgrade the SOHO coronagraph three times, and this will be the fourth attempt.

NASA intends to select two primary explorer missions with their own rockets and one or two "missions of opportunity," in which an instrument is added to somebody else's spaceship. The coronal observatory would be a mission of opportunity.



A 45-foot-long instrument used to calibrate probes that study the sun. Now housed at Harvard, Reisenfeld hopes to bring it to UM.

Forty-two proposals were submitted to NASA during this most recent solicitation, and Reisenfeld's team learned in September that the Coronal Physics Investigator had made the cut to the next round.

"The next step is to carry out a concept study that would be due next September," he said. "The final selection will be in March 2013."

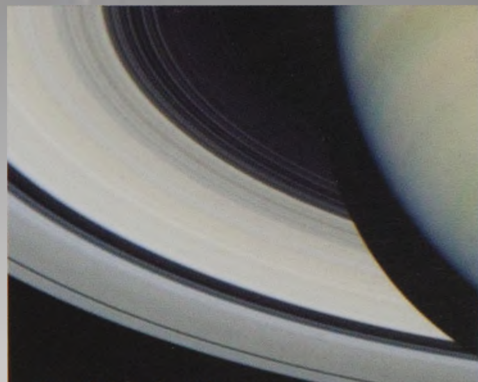
If funded, the UM portion of the project would receive $4 million over six years. It also would bring a 45-foot-long instrument used to calibrate sun-studying space probes to UM, where the one-of-a-kind device would be reassembled in the basement of the Interdisciplinary Science Building. Right now the instrument is in pieces at a Harvard warehouse.

"If this happens, we would be the only place in the world that could build instruments like this," Reisenfeld says.

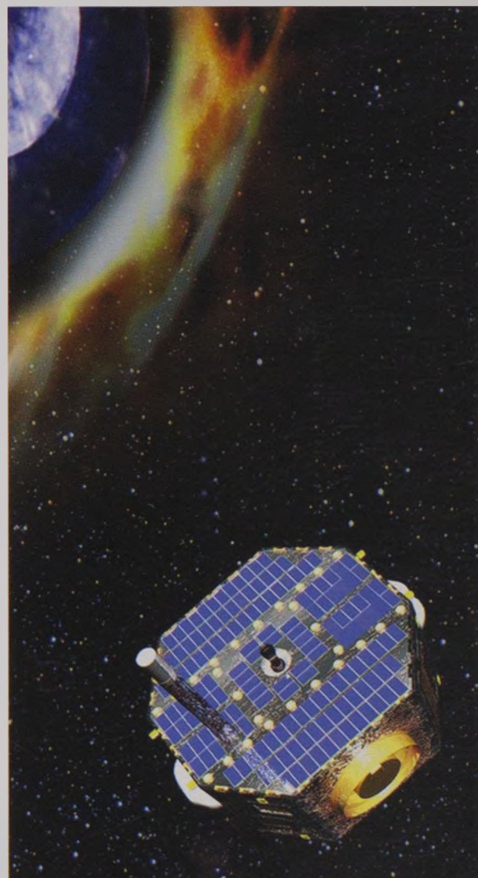
He loves that the interconnected modern world allows him to design probes and do advanced space science while living in the mountains of Montana. He also enjoys the opportunity to teach UM students and share his NASA experiences with them. In addition, he gets to employ some of Montana's brightest undergraduate students in his laboratory to work on projects such as the Coronal Physics Investigator.

"I'm very excited about that proposal, but if we don't get it, we'll propose something else," Reisenfeld says. "It's not this or nothing. One way or another, we'll get that unique world-class instrument here to UM." V

For more information email dan.reisenfeld@umontana.edu.



Cassini Saturn image



A NASA artist's rendition of the IBEX spacecraft

Rhea, the second-largest of Saturn's moons *(NASA image)*

Planting New Ideas

UM ecologist promotes concepts of plant community interdependence

By Deborah Richie

UM's Ray Callaway in a dense cluster of knapweed

High on the wind-scoured ridges of Lolo Peak south of Missoula, cushion plants survive blizzards and frigid temperatures. You can find them on peaks around the world. The species may be different, but many support a community of plants nestled within the cushion mats. The best way to investigate the miniscule neighborhood is to lie down and look closely – hence the nickname "belly plants."

For UM Division of Biology Professor Ragan (Ray) Callaway, cushion plants exemplify a brilliant ecological process in nature that ecologists call "facilitation." That term refers to how one plant facilitates the survival of another or perhaps several that all live together in a community. Callaway, who has taught at UM for the past 18 years, is one of the world's experts on plant facilitation.

"We are finding that stress tolerant, tough, alpine cushion plants are fundamental drivers of biodiversity in alpine systems," Callaway says.

A cushion plant escapes brutal winds by growing low to the ground, and its dense, leathery leaves raise temperatures at the leafy surface. The cushion structure and warmth benefits fragile alpine flowers that grow within its microclimate. In addition to competing with one another, these alpine communities prosper via cooperative strategies.

Callaway is part of a 10-member international team studying alpine ecosystems in 80 sites around the world, including the Alps, the Caucasus, the Andes, the Brooks Range in Alaska, New Zealand's Southern Alps, the Pyrenees and the Rocky Mountains. For the past 15 years, the "Alpine Pals" have studied more than 60 species of cushion plants and some 2,000 species that share the rugged life of mountain summits.

"Cushion plants have evolved from more than 50 different plant lines," says Callaway. "They're beautiful examples of convergent evolution."

In other words, very different kinds of plants have evolved into a cushion shape to colonize some of the harshest places on Earth. In Montana the moss campion cushion is in the carnation family, while in Latin America cushion plants belong to aster and carrot families. There's even a cactus cushion.

Plant communities seem to keep knapweed under control in its native Eurasia. That's not the case in Montana.

Callaway is known for taking a biogeographic approach to understanding how plants behave. He's trekked to Central Europe to research knapweed in its native habitat. There, he found it growing individually or in very small patches, nothing at all like the swathes threatening native plant diversity in the western U.S.

"For invasive plants, you have to know how they function in their native environment to understand why they explode here," says Callaway. "For cushion plants, we can look at what part of the evolutionary tree they came from and how that affects the way they increase diversity."

Whether studying cushion plants or invasive weeds, Callaway's work demonstrates a key concept that has recently transformed plant ecology. Only a decade ago most ecologists accepted the premise that plants are individualistic in behavior. Callaway was one of the first modern scientists to challenge that accepted view. In field experiments, he found that plants often depended on one another. Later, teaming up with a wide range of collaborators, he documented numerous examples of facilitation, a clear indication of interdependence among plant species.

Interdependence has big implications for conservation, according to Callaway. It means that the loss of a seemingly insignificant species may harm other species in that community.

In the plant ecology world, competition is often cited as the primary, or most important, interaction. What Callaway and collaborators have discovered is that in harsh environments, such as mountaintops or the upper limits of intertidal zones, plants thrive by helping one another out. They serve as positive facilitators.

For example, near timberline in the Northern Rockies, whitebark pine is the dominant tree. At the highest elevations, subalpine fir grows close to whitebarks that protect them from icy storms. The death of the pine results in poor growth for the fir. However, as you descend from treeline, the strategy changes to competition between whitebarks and subalpine firs.

Callaway assembled enough compelling data to write a groundbreaking 415-page textbook, "Positive Interactions and Interdependence in Plant Communities," which was published in 2007. He lays out his well-documented case in the first few pages:

Callaway samples cushion plants in New Zealand's fog-shrouded high country.

"In this book I argue that plant communities are not simply suites of species that happen to be dispersed to and adapted to the same biotic conditions at a given place. I argue that many if not most plant communities have fascinating interdependent characteristics, with some species creating conditions that are crucial for the occurrence and abundance of other species."

That big-picture thinking has earned Callaway high standing among scientists worldwide, says John Maron, UM professor and director of the Organismal Biology and Ecology program (OBE) that includes Callaway's lab.

"The bottom line by any metric is that Ray is having a huge influence on the field," Maron says, noting Callaway's litany of published work, international talks, citations and papers reviewed. Callaway's research has appeared in many premier scientific publications.

Callaway's name appears most recently with three co-authors in the June 2011 edition of Science. Their article, "Terrestrial Ecosystem Responses to Species Gains and Losses," weaves together existing research to make the case that losing a species or adding a species has big impacts on ecosystems across the globe and both should be studied simultaneously.

While Maron showers praise on Callaway for his out-of-the-box thinking and his productivity as a published professor, he adds a playful caveat to his compliments. It happens that Maron is more of a population ecologist, while Callaway is a trained community ecologist.

"Our offices are next door, and we go to the gym and we talk about our subjects all the time," Maron says with a laugh. "We disagree about as much as we agree on, but we are good friends. Disagreeing is tremendously valuable because it forces you to look from a different perspective."

Maron is proud of the OBE division he has directed for the past two years and the spirit of cooperation, engagement and creativity that dominates their lively faculty gatherings. Callaway's position of seniority often puts him in a leadership

Three examples of high-elevation cushion plants: (Top) Jones' columbine in Glacier Nation Park, (Middle) Azorella madreporica in the central Andes of Chile and moss campion in Glacier National Park.

role, yet he doesn't take himself too seriously, Maron says.

"It's fun to be an underdog," he says of comparing the OBE division to the most prestigious institutions, "but now we are totally on other scientists' radar, and we hear them say, 'you're an awesome group.'"

Scientists from around the globe regularly visit the faculty housed in the modest old Natural Sciences Building by the University greenhouse. They particularly want to spend time with Callaway.

"He's such a collaborator, and they want to soak up some of the magic," Maron says.

On a late summer day among the drying grasslands of Mount Jumbo, I join Callaway for a chance to see the all-too-familiar spotted knapweed from a scientist's viewpoint. He breaks off a piece and shows where grasshoppers have stripped the stem, a minor setback to the hardy weed that's easily identified by its thistle-like, purple-pink flower.

We take a closer look at the plant's deeply lobed leaves. He tells me the leaves might contain fungi that help knapweed spread even more quickly than expected. Some knapweed carry the fungi and some don't, according to research by one of Callaway's graduate students, Erik Aschehoug.

To successfully control knapweed takes a holistic understanding of all its weapons – from fungi power to deadly chemicals in its roots that makes the soil toxic for native plants like bunchgrasses, Callaway says.

Back in its homeland, knapweed has long associations with its neighboring plants and the microbes in the soil. There, knapweed's array of weaponry has little impact, because over eons its fellow organisms evolved ways to defend themselves, Callaway says. In our country, knapweed dates only to the early 1900s, when it sneaked into the U.S. from Eurasia among alfalfa and clover seeds.

Given the multipronged strategies for invasion, Callaway doubts that introducing predators from Eurasia will succeed, and those come with their own risk as well. Instead, he advocates preserving as much plant diversity as possible. Knapweed has a harder time gaining a foothold among healthy ecosystems, he says.

Chatting with Callaway in the field and in his office, I noticed he'd much rather talk about the work of his collaborators and graduate students than his own research.

He tells me that graduate student Marnie Rout recently discovered the main mechanism for invasion by one of the world's worst exotic grasses. Called Johnson grass, this plant has proved to be bad news in Texas, drastically reducing native diversity. Rout found that the invader is enslaving a suite of bacteria in the soil to fix nitrogen and other services just for itself, and to the detriment of the native grasses. Rout's research required a series of molecular, biochemical and experimental tests that Callaway says he can only admire.

"I take the shovel-and-hand-clipper approach to ecology," he says. "I do simple experiments, like removing neighboring plants to see what happens."

Accompanying his simple approach is an insatiable curiosity and a search for patterns and meaning.

"My whole career has been like that," he says. "I see a pattern in the field and get interested."

He says he stumbled upon his doctoral research at the University of California, Santa Barbara, by noticing unusual patterns among the blue oaks on the hillsides. He wondered why some of the trees sheltered myriad plants, while other oaks had nothing growing under them. He found that the oaks that sent their taproots straight down into the groundwater left plenty of space near the surface for grasses, flowers, and shrubs to flourish in the welcome shade. In contrast, the blue oaks that struggled to find water sent out a dense network of roots close to the surface. The roots overrode the facilitating (positive) effect of the shade and prevented understory plants from gaining a toehold.

After earning his Ph.D. in 1990, Callaway continued his exploration of plant interdependence and facilitation. He takes the same method of inquiry today as he did more than 20 years ago.

"I head down the trail and ask goofy questions about nature," Callaway says.

His colleague Maron views him slightly differently. "One of the marvelous things about Ray is he is very much an idea guy. While ecologists often debate nitty-gritty details about how to do science, the field is still motivated by ideas, and Ray has had his share of good ones." V

For more information email ray.callaway@mso.umt.edu.

FINDING FAULTS

researcher maps earthquake zones to help those at risk

By Deborah Richie

UM earthquake expert Rebecca Bendick enjoys some tea in the Pakistani portion of Kashmir.

To join Rebecca Bendick in the field, plan on packing sturdy hiking boots for a trek to far horizons. Her research into the nature of interior continental earthquakes and efforts to help people survive them often takes the UM geosciences professor to the far-flung peaks of Central Asia and even into Ethiopia.

"I've always loved mountains," Bendick says. She has the compact and slim build of an athlete who frequents the rarefied air of the Himalayas. "And where do mountains come from? Faulting and other geological processes. My career has taken me to some beautiful places. "

It's not surprising that her profession would lead to a position at UM in 2005. Missoula overflows with people similarly drawn to rocky crags. Before joining UM's geology department, she spent two years at Cambridge University in England. Bendick earned her Ph.D. from the University of Colorado.

Choosing earthquakes within continents as a focus also has given Bendick the chance to experience life in remote villages of Tibet, Nepal and other Central Asian countries. She's shared meals, small talk and laughter with the people who are most at risk of losing their lives to catastrophic earthquakes. Her personal ties shows up on her UM website (http://www.umt.edu/geosciences/faculty/bendick), which is replete with their images:

A woman with a radiant smile and dressed in a magenta flowered robe squats next to her outdoor cooking pot. An elderly woman sells wild mushrooms arranged on platter-sized leaves. And two small girls with their arms around each other gaze earnestly into the camera. One wears a red plaid headscarf, and the other sports a flower in her windblown hair.

Then there are the photos, too, of devastation in Pakistan after the 2005 earthquake – as three men in rags walk past the rubble of a three-story building. An abandoned military tank in the arid mountains of Afghanistan serves as a reminder that natural disasters are not the only dangers of the region.

In April 2011, Bendick joined a select number of scientists invited as delegates to a high-level exchange between the Chinese and U. S. governments in Chengdu, China, 50 miles from the epicenter of the 2008 Wenchuan earthquake. She co-chaired a workshop and spoke on where and why interior earthquakes are more difficult to forecast and simulate then on coastal tectonic plate boundaries, such as this year's earthquake and tsunami in Japan.

"Most of the places I work are so remote and obscure that people haven't noticed the big faults," she says. "As a result, hundreds of thousands of people have died in the last decade alone."

China's 7.9-magnitude Wenchuan earthquake in precipitous Sichuan Province killed more than 90,000 people. Schools and hospitals collapsed. Many children died. In Pakistan the 7.6-magnitude Kashmir earthquake of October 2005 led to the deaths of 73,000 people.

To investigate the forces responsible for destructive earthquakes, Bendick and her graduate students team up with local scientists to gather field data that can be translated into hazard maps.

"Surprising earthquakes come in two flavors," she says. "There are those that scientists genuinely don't understand and could never forecast and those that are not theoretically surprising but a problem of lack of access and study."

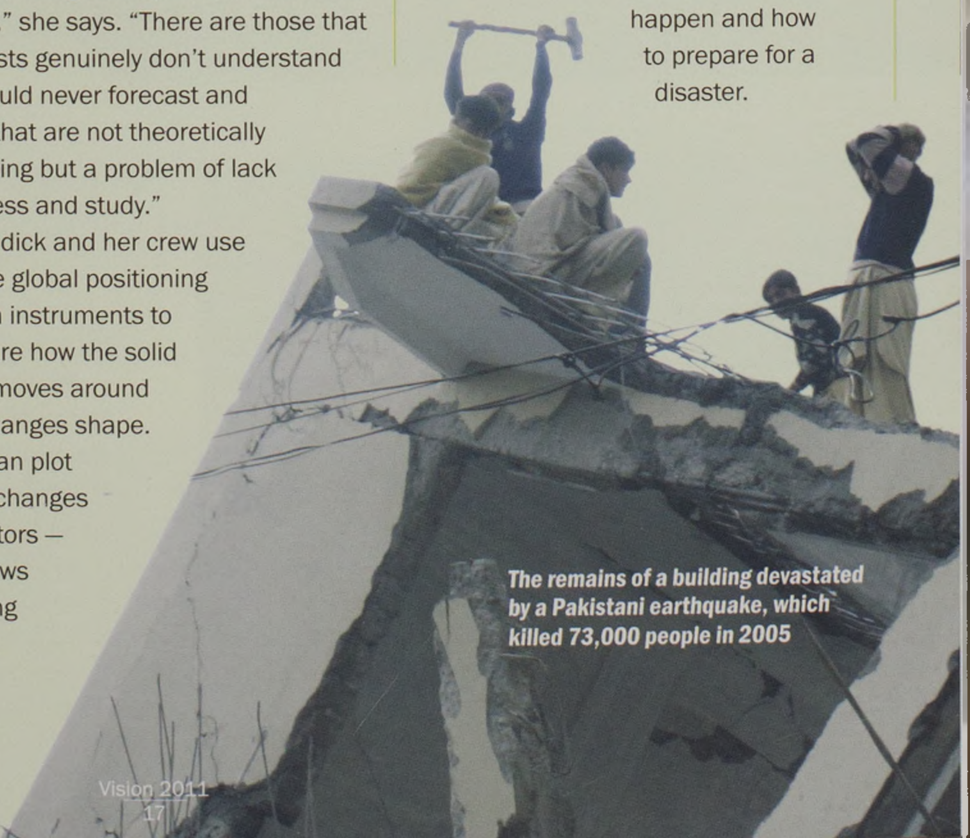
Bendick and her crew use precise global positioning system instruments to measure how the solid earth moves around and changes shape. They can plot these changes as vectors — or arrows showing speed and direction. The longer the arrow, the faster the movement. When speed or direction of the rocks in a continent varies in space, the result is storage of energy to build mountains and cause earthquakes.

She explains it this way: Suppose you did the same experiment, not with rocks, but with one car stopped at a light and another one speeding up behind. The stopped car would have a vector of zero length; the speeding car would have a long vector. The difference in their speed tells you how much energy goes into a crash if the fast one doesn't pay attention. It's the same thing in a continent — different speeds or directions forecast a car crash in the making.

The mapping from 10 years worth of data also serves a practical humanitarian purpose that is gratifying to Bendick.

"While it's nice to know more than we did yesterday, after going to these places time and time again after humongous earthquakes, it slowly became obvious that there is a break in the chain of communication that keeps scientific results from getting to the people who need them," she says.

Tribal leaders have little use for complex scientific papers, she points out. What they need instead is practical information that tells them where an earthquake might happen and how to prepare for a disaster.



The remains of a building devastated by a Pakistani earthquake, which killed 73,000 people in 2005

A building nearly toppled by the 2008 Wenchuan earthquake in China was allowed to remain standing for scientists to study. Bendick was invited to visit the area this year.

UM researcher Rebecca Bendick visits a wrecked hotel in Pakistan 10 days after a devastating earthquake in 2005.

Bendick spent the early summer in Central Asia conferring with the Aga Khan Development Network, a group of development agencies dedicated to improving the lives of impoverished people in Asia and Africa. The nonprofit group employs 80,000 people and has an annual budget of $625 million. The network recently added earthquake-resistant construction as a high priority.

By the end of 2011, Bendick will complete a Central Asia earthquake hazard map for the network. The high-risk areas on the map will identify top priority areas to spend funds that will shore up schools, hospitals and homes, and assure a ready stock of emergency supplies.

Microfinance loans will incorporate risks as well. For instance, if an Afghan villager applies for a $100 loan to add a room, the network would give him an additional $30 to pay for sturdier construction. Bendick believes the loans are the most powerful part of the program, because they engage villagers directly in the process of earthquake preparedness.

"We have the potential to positively impact millions of people," she says. When an earthquake hits an unprepared remote area with shaky buildings, one-third of the deaths take place immediately, but two-thirds happen over the next week from thirst, starvation and disease.

Mapping Tsunami Pathways

When Mark Lorang looks at boulders shoved inland by ocean waves, he wants to know how they got there. Was it a big tropical storm? A tsunami? The answer lies in the nature of the boulder deposits.

The UM research associate professor in geomorphology has come up with a physics equation that may allow scientists to better differentiate between the two forces.

"The problem today arises when a tsunami hazard map is made from mapping boulder deposits that are assumed to be from tsunamis," he explains. The better the mapping, the better the planning can be to avoid building in potential tsunami pathways.

While based far inland at the Flathead Lake Biological Station, Lorang is no stranger to coastlines. His doctoral dissertation in oceanography from Oregon State University in 1997 delved into how boulder and gravel beaches behave under the force of incoming waves.

Lorang looked not only at the height and velocity of waves, but at the wave period (the intervals between waves). That investigation of wave period applies to his new equation.

"The period for a hurricane storm waves is on the order of 30 seconds maximum, while the wave period for tsunami

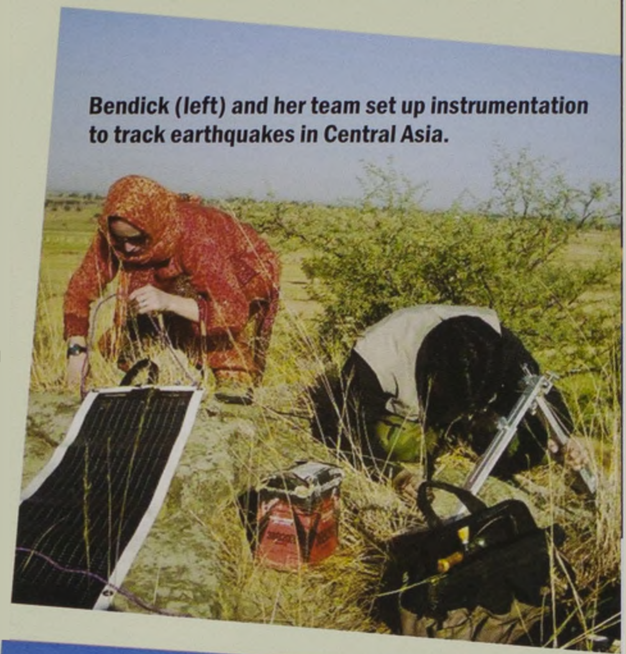
"Fortifying key buildings and preparing rapid response would save more than half the people," she says.

Closer to home, Bendick recently began a five-year project in southwest Montana near Dillon, a region that includes the site of the 1959 Hebgen Lake earthquake and the 1983 Borah Peak earthquake. The data collected will produce a picture of the size and scale of the tectonics, yielding key information for determining the underlying physics.

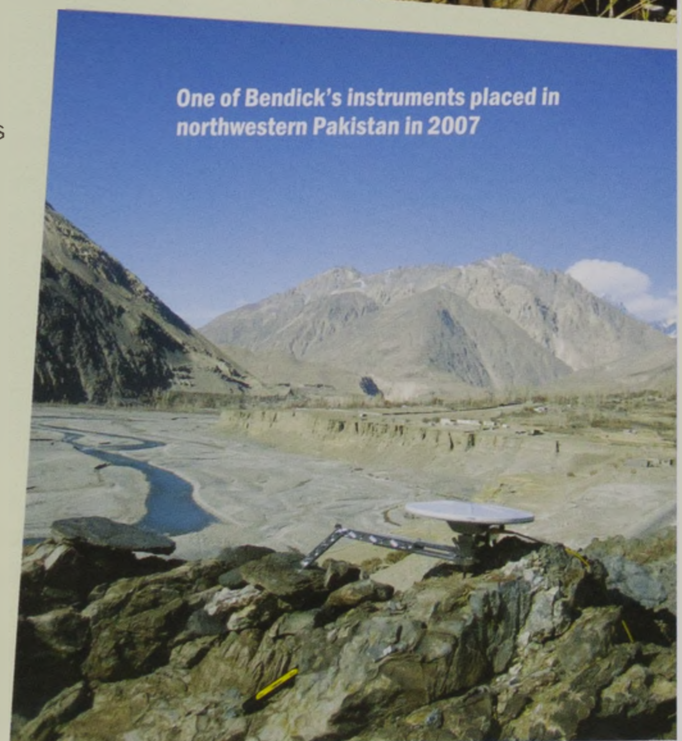
Every time she heads to her new field site, sometimes with her 2-year-old daughter in tow, Bendick also mentally prepares herself for an emergency call that might take her to Asia. She's part of a team of scientists who will rush to the scene of an earthquake to learn and apply that knowledge — ultimately to save lives. V

For more information email bendick@mso.umt.edu.

(Left) Some of the interesting people Bendick has encountered during her journeys in earthquake country

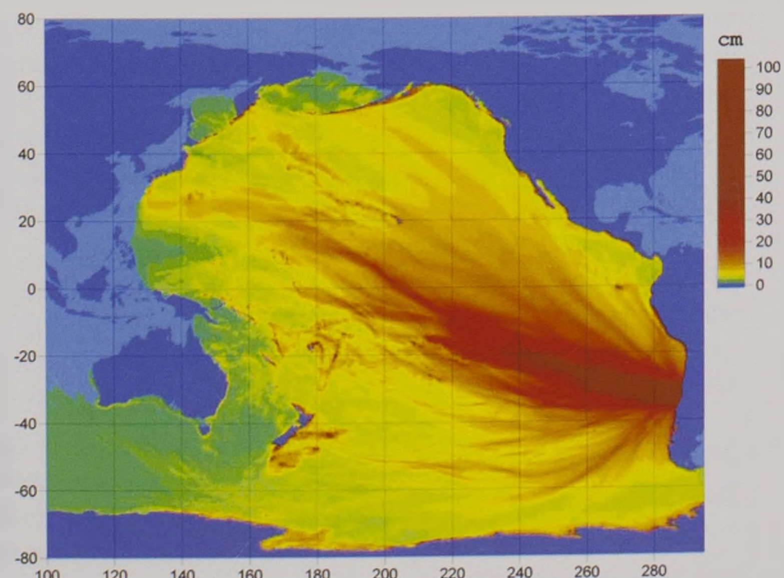


Bendick (left) and her team set up instrumentation to track earthquakes in Central Asia.



One of Bendick's instruments placed in northwestern Pakistan in 2007

This National Oceanic and Atmospheric Administration graphic shows the radiation of energy from a tsunami originating in Chile in February 2010. The graphic is a plot of estimated deep-water wave height.

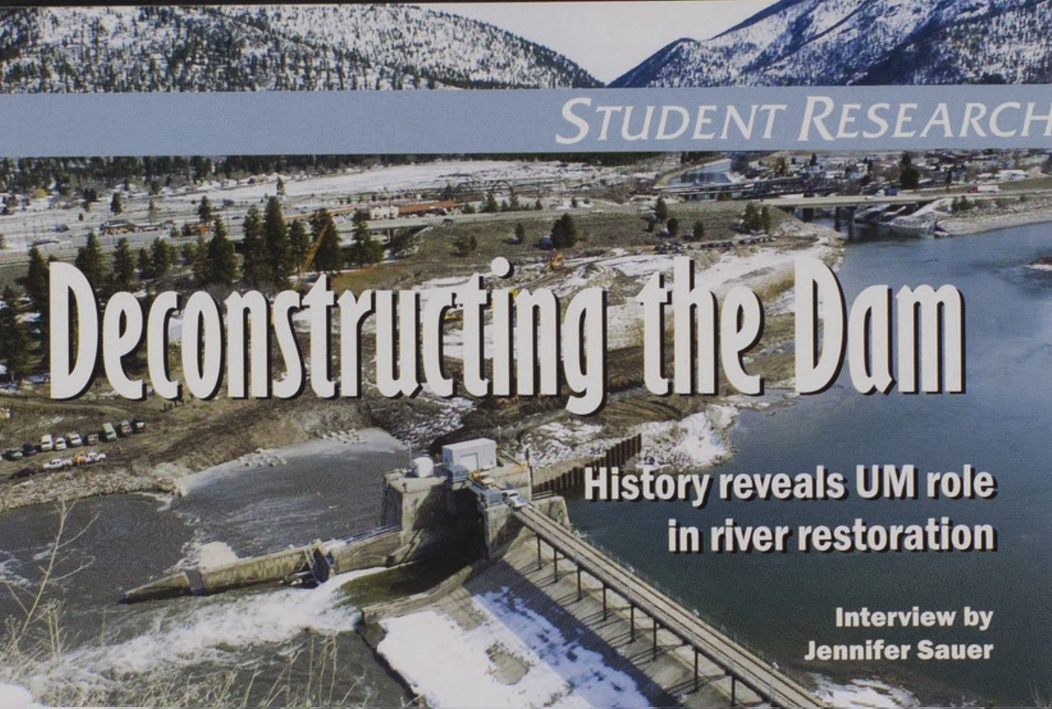


waves is on the order of 10 to 15 minutes and much longer," he says. "The longer the wave period, the more time each wave has to push and shove boulders farther inland and higher up the slopes."

Lorang published the new equation in the May 2011 issue of Marine Geology. This fall, Lorang will travel to France to work with researcher Raphaël Paris to test the equation more fully.

"This paper puts The University of Montana on the map in an area most people would not expect," Lorang says. V

For more information email mark.lorang@umontana.edu.



Deconstructing the Dam

History reveals UM role in river restoration

Interview by Jennifer Sauer

The image shows Milltown Dam on the day a side channel was breached in March 2008, allowing the Clark Fork River to flow freely past the dam for the first time since 1907.

David Brooks, a doctoral student in UM's Department of History, is writing his dissertation on the history of the Milltown Dam Superfund site located east of Missoula in the Clark Fork River basin. As he researched his project, Brooks noted that several UM faculty members, students and graduates from a variety of departments played a key role in the process that guided the reclamation of the site. Brooks recently talked about the people who had a hand in the evolving project, from the time arsenic was first detected in Milltown wells, to the evolving discussion on how to manage the contaminants, to the eventual removal of a dam that stood for more than a century.

How did you come up with the idea for your dissertation project?

My area of interest has been U.S. environmental history as well as the American West. The dissertation project idea that I brought into the program was doing a history of the Milltown Dam, which really has become a history of the Superfund process. What I am trying to write is the history of how Superfund has played out using this as a case study – particularly as a case study of how it has worked well and the changes in the implementation of Superfund and its now 30-year history. It matches with the 30-year history of Milltown because it was designated on the national priorities list as a Superfund site on the very first round.

Why is the history of the Milltown Dam Superfund site significant?

At the time Superfund legislation was passed [in 1980], the designation was mostly about fencing [the sites] off, preventing them from causing any more harm to human health. I think Milltown is the best example, if not one of the forces behind, turning Superfund cleanups into environmental restoration projects. Now they are actually trying to restore environments to some semblance of naturally functioning ecosystems rather than just containing toxic waste.

How did UM faculty members first become involved with the Milltown Dam Superfund site?

In 1981 just after Superfund law was passed, a guy in Milltown called up the health department complaining about his water. Somebody from the health department went out and found just obscenely high levels of arsenic in the drinking water. [UM Regents Professor] William Woessner, who teaches in what is now called the geosciences department, and his colleague [geosciences Chair and Professor] Johnnie Moore were both fairly new faculty. Woessner heard about this and got $25 from his department to rent a chain saw to cut through the ice in the reservoir and take some samples. He and Johnnie Moore and a couple of grad students went out in the winter and found that there was all kinds of arsenic in the sediment over there. That was really just the beginning of their participation with Milltown.

When I go through all the EPA records and read all the studies, the lion's share of them were done by William Woessner and Johnnie Moore. They really did most of the research that the EPA has relied on at that Superfund site. No doubt the story would be different had those two guys not been here to do that.

What kind of role did UM students play in the history of the Milltown Superfund site?

I was just riding my bike over the footbridge here, and there's a group of eight or 10 students out in the Clark Fork right now netting fish. Some of them might write a paper on it; it might be an exercise in methodology for some of them. This has been a Superfund site, so it's been a great laboratory for UM students and faculty.

How did some of these UM graduates take the research they did around Milltown as students and turn it into a career?

Peter Nielsen was a grad student in environmental studies doing his master's beginning in 1980. Before Milltown Reservoir was designated as a Superfund site, he had been studying, as a student, and protesting, as a local river user and concerned citizen, the drawdowns that the Montana Power

Company would do of the dam.
Once it got designated as a Superfund site, Nielsen helped start the Clark Fork Coalition. He was its first director. He parlayed his early activism and interest in water-quality issues as a UM grad through the Milltown Dam into being a government agent with the Missoula health department's Water Quality Division and an advocate for clean water and environment. He's been a key player from beginning to end.

Michael Kustudia is another example of that. He was in the EVST department and finished up his master's in watershed conservation in 1997. He went on to become the head of the Clark Fork River Technical Assistance Committee, which was the public relations organization for the EPA. He's now become the first manager of the new Milltown State Park. The area is being restored, and now the land will become a state park. This is the third phase of the three Rs: remediation, restoration and now redevelopment. This is the redevelopment part that now Michael has a major hand in coordinating.

David Schmetterling did his master's in wildlife biology at UM in the mid-'90s and started with Fish, Wildlife and Parks in 1995. In 1998 he started studying the question of how many fish and what kind of fish was the dam actually blocking. He started finding that like 200,000 fish a year were being backed up by the dam, including native fish like cutthroat trout and particularly bull trout. David mentored a number of graduate students in wildlife biology through his studies of fish.

Not all the people involved have made it into my story about the Milltown Dam or are recognized as major figures in that story, but it just goes to show how involved UM has been in watershed work around here, both people studying as students and then what they go on to do with their degrees.

Who helped bring the idea of removing the dam to the table?

We think of it now as the Milltown Dam Superfund site and what happened with the dam because it got taken down and that's big news. But it did not start out as a dam issue. It started out with the reservoir and the contaminants in the reservoir. There was no discussion of needing to take down the dam. That didn't happen really until the floods of 1996 that threatened to wash out the dam. Shortly thereafter, a woman by the name of Tracy Stone-Manning, a UM EVST graduate student, did her thesis on environmental advertising. Her idea was "how can environmentalists use advertising to attract more people to causes in the same way that businesses use advertising to attract consumers?"

She became the director of the Clark Fork Coalition about two years later and really put those issues into play around the Milltown Dam. She was really the inspiration behind the campaign to remove the dam that started between 1998 and 2000. She did exactly what she had studied in her thesis, which was to make environmentalism — in her own words — sexier, funny, entertaining, in a way that it hadn't been before. Probably the most popular thing they did was produce bumper stickers that simply said "Remove the Dam; Restore the River." And that phrase really caught on. The idea was that the Superfund process could be about both things; not just remediating the problem of the toxic sediment behind this old leaky dam, but actually restoring an ecosystem.

The involvement of UM faculty and students in the Milltown Superfund site project spans several different departments. Why is that?

Superfund law, like any federal public policy, is just a massive law. There are a lot of different ways to be involved in the Superfund process. These are the names that I know and that I have focused on in my story, but there are plenty of others. The point is that people have come to it from a lot of different departments and a lot of different angles. They have used their education here at UM to continue to be involved in the Milltown issue or to become involved through putting their education to use.

UM doctoral student David Brooks has spent untold hours in the Maureen and Mike Mansfield Library to help prepare a history of the Milltown Dam Superfund site.

Why do you think UM faculty, students and grads were drawn to working on the Milltown Superfund site?

Nationally, Superfund has been controversial through its entire history. But when you talk to people about Milltown, nobody talks about the law itself. What they talk about is how different individuals have affected the process. Again and again, I wind up hearing about individuals who came through UM as many of the key people. As a historian, I find that interesting. This is a major Superfund site and that law is important, but really what's caused change are individuals. And all of them certainly emphasize their education as the part of the reason they moved the direction they did. Most of the people I talk to came to Missoula to go to UM but also just because of their love of the area and, for all of them in different ways, their love of rivers and being outdoors, which this place has to offer. I wouldn't be the first person to recognize that that's a huge attraction to a lot of students here: not just the school, but the place. And these are people who have appreciated that and wanted to give back. V

BACTERIAL BUDDIES

Research reveals fascinating relationships between insects and one-celled stowaways

By Deborah Richie

Scientist John McCutcheon, shown here with a cicada, studies mutually beneficial relationships between insects and bacteria.

These mealybugs, *Planococcus citri*, contain two distinct species of bacteria – one living inside the other – which provide the insects with essential amino acids.

Photo by Lyle Buss, University of Florida

"If you study diversity, you find interesting things," says John McCutcheon, who joined the faculty of UM's Division of Biological Sciences in 2010. "And this diversity does not need to be found deep in a remote jungle or on the bottom of the ocean, but can be right outside your door."

You might start with spittlebugs, cicadas, aphids and mealybugs, which are all sap-feeding insects. Sap is a nutrient-poor food that cannot supply the insects with the 10 essential amino acids needed for life. Instead, they rely on bacteria to make it for them, and in turn the bacteria have a cozy place to inhabit inside the insect — a symbiotic relationship.

Bacteria, plants and fungi have the ability to manufacture all 20 amino acids, while animals must obtain the 10 essential amino acids from their diet.

McCutcheon's recent co-discovery of the metabolic partitioning between two bacterial species dwelling within mealybugs borders on the fantastic. He and Utah State University's Carol von Dohlen found a level of integration never before observed among three organisms. Their research appeared in the Aug. 23 issue of Current Biology and is titled "An Interdependent Metabolic Patchwork in the Nested Symbiosis of Mealybugs."

"In this symbiosis, both bacteria live in the cytoplasm of special mealybug cells, and one bacteria lives inside of the other," he says. "To make some essential amino acids, different enzymes are contributed from all three organisms in the symbiosis. The survival of the entire system is dependent on these enzymes, which are produced in a remarkable patchwork pattern."

Specifically, a bacterium called *Moranella* (named after McCutcheon's mentor, Nancy Moran) nests within a bacterium called *Tremblaya*, providing it with parts of the essential amino acid pathways it lacks. The *Tremblaya-Moranella* composite nests within mealybug cells and supplies essential amino acids (or some of their precursors) to the mealybug.

The amazing relationships McCutcheon explores in his work may lead to practical applications for agriculture. Many sap-feeding insects are serious crop pests, such as the citrus mealybug and the glassy-winged sharpshooter. He has a new U.S. Department of Agriculture grant to study the stinkbugs that are invading soy crops in the southeast in high numbers.

"If you kill the symbionts, you kill the insect," he says. "So there's a real interest in exploiting knowledge of the symbionts for pest control."

McCutcheon began his research delving into sap-feeding insects and their bacterial symbionts as a postdoctoral fellow at the University of Arizona in 2006 under the tutelage of Moran, who has long studied the evolution and ecology of aphids and their beneficial bacteria.

Aphids live by sucking sap from the phloem (nutrient-transporting tissue) of plants and secreting sweet honeydew that attracts ants. For anyone strolling the UM campus this past summer, they personally experienced the sticky leaves stuck to the bottom of their shoes — all honeydew residue from a bountiful aphid season.

The challenge that intrigued McCutcheon as a postdoctoral fellow was to expand Moran's study from aphids, which have one symbiont, to a different group of sap-sucking bugs with more than one bacterial symbiont.

While Moran came to her subject of insect and bacteria co-evolution because of a lifelong interest in bugs, McCutcheon admits he hadn't thought much about them until his postdoctoral work. His doctorate is in computational biology.

"I'm really into them now," he says with a grin. Some of his main subjects live just outside his office, such as the spittlebug larvae that cover themselves in bubbly foam for protection and the cicadas that sing in the trees on campus.

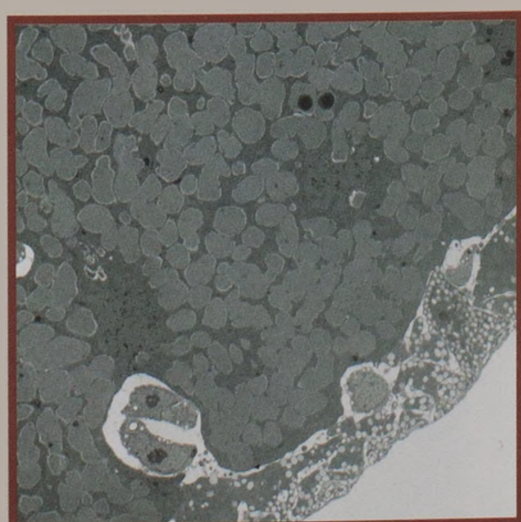
BACTERIA: Small Yet Vital

Bacteria often have a bad rap. While a minority of these single-celled organisms cause nasty diseases, humans rely on thousands of bacterial species living in and on us to help us digest food, protect our skin, build up proper immune responses and several other key functions. From 500 to 1,000 species of bacteria inhabit the human gut alone.

"We're more bacterial than human in terms of cell count," McCutcheon says. "There are about 10 times more bacterial cells in your gut alone than there are human cells in your entire body."

In addition to their relevance to us, bacteria are amazing in their own right. According to geologic studies, bacteria have been on Earth for some 3.5 billion years.

"This antiquity has given them time to evolve biochemical pathways to live just about anywhere and eat just about anything," McCutcheon says. Bacteria thrive everywhere, from the hot springs in Yellowstone National Park to the underside of Antarctic glaciers. V



A transmission electron micrograph of a thin section of a spittlebug bacteriome, an organ that houses bacteria useful to the insects

A cicada beneath a microscope in McCutcheon's lab

"You can actually see the organs that contain the bacterial symbionts in some spittlebugs," he says. "Just pick one out of the spittle and turn it over and look for a couple of bright orange, red or yellow dots near the back end of the insect."

Spittlebugs, cicadas and sharpshooters are the group of sap-feeding insects that McCutcheon selected for the array of potential symbiotic bacteria to study. The group differs from aphids and mealybugs, which passively sip the sap from a plant's phloem. Instead, they are xylem feeders that have to suck hard to extract liquid from the primarily water-carrying part of a plant. The insects tend to have big heads to house the large sucking muscles that help with the arduous task. In addition to being under negative pressure, xylem sap is more nutrient-poor than phloem.

"From old microscopy, there was known to be a huge diversity of bacteria within the insect group containing spittlebugs, cicadas and sharpshooters," he says. "But these bacteria cannot be grown in the lab, so it wasn't until the advent of modern genome sequencing methods that we had the opportunity to study how these bacteria are associated with insects."

He focused on the *Sulcia* bacteria that has co-evolved with the three insects for 270 million years. Over time *Sulcia* lost the ability to make all 10 amino acids and had to pick up a partner. The two bacteria share the same cells, rather than nesting in each other, like with the mealybug.

Sulcia produces seven of the 10 essential amino acids in the spittlebug. Bacteria called *Zinderia* makes the other three. In the cicada, *Sulcia* makes eight, and the bacteria *Hodgkinia* adds the missing two amino acids. The sharpshooter has a similar ratio, but *Sulcia* has a different partner symbiont called *Baumannia*.

"In each case, the insect depends on the metabolic contributions from the two bacteria. Their duties are distributed in complementary and nonoverlapping ways," McCutcheon explains.

The complex symbiosis of bacteria within the sap-feeding insects is even more remarkable when you consider the genetics of these one-celled microorganisms.

"The bacteria we're studying have such reduced genomes that they live at the extreme end of the spectrum," he says. "With so few genes, it's a complete mystery how the symbionts survive."

A genome carries the instructions for an organism to make the proteins and enzymes it needs to live. *Tremblaya* has the smallest bacterial genome in the world, with only 121 protein-coding genes. In comparison, the *E. coli* bacterium has 4,100 genes. People have somewhere around 24,000 protein-coding genes.

McCutcheon hopes that examining bacteria with super small genomes may help illuminate the evolutionary point where bacteria become organelles – organ-like structures within cells – and lead to more knowledge of mitochondria, the power producers of cells. Like the symbionts McCutcheon studies, mitochondria used to be free-living bacteria. In the process of becoming an organelle, mitochondria also lost many genes, similar to what is observed in the insect symbionts such as *Tremblaya*.

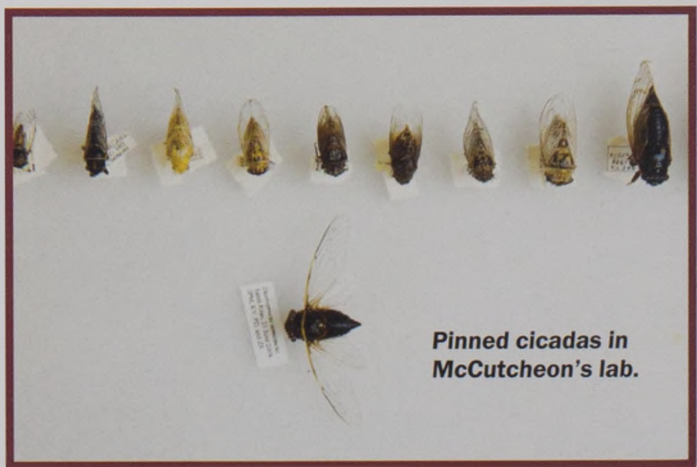
His lab applies the latest technology to rapidly, efficiently and cheaply sequence bacterial genomes. The researchers remove the insect organs that have the bacteria and purify the DNA. Since about 80 percent of the DNA comes from the insect, it takes many sequences to find and identify the bacteria DNA.

"For mealybugs, we sequenced over 2 billion bases," he says, "and only then could we pull out the bacterial symbiont genomes."

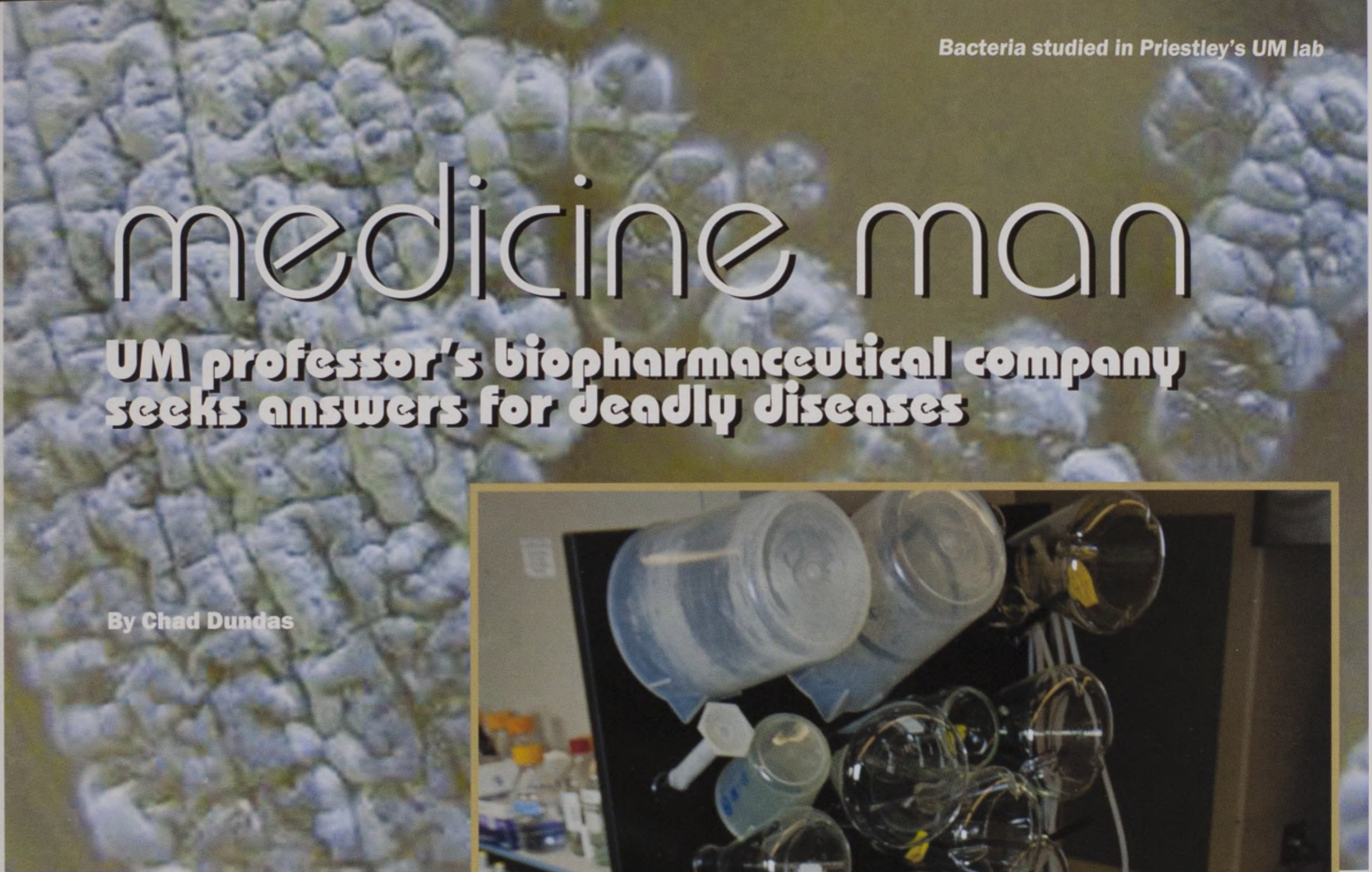
McCutcheon makes a compelling case for the wonders and necessities of diversity revealed when you tease apart life at miniscule levels.

His next line of inquiry is to examine how such small genomes can function. "How can these bacteria have such tiny genomes, encoding so few genes, and still be alive?" V

For more information email john.mccutcheon@umontana.edu.



Pinned cicadas in McCutcheon's lab.



Bacteria studied in Priestley's UM lab

medicine man

UM professor's biopharmaceutical company seeks answers for deadly diseases

By Chad Dundas

Chemistry Professor Nigel Priestley has worked at UM 12 years and formed the company Promiliad Biopharma, which may someday cure some of the world's deadliest diseases.

Nigel Priestley stores the past decade of his life's work in an ordinary-looking refrigerator at a nondescript lab on the third floor of the UM Chemistry Building.

Tucked away against a bank of windows at the back of the lab, the fridge is white and blocky and — except for the small orange biohazard sticker mounted front and center — looks very much like something you might find in a residential kitchen. Inside, however, it's anything but ordinary.

When Priestley pulls open the door, he reveals that the refrigerator is stacked with small plastic racks, each bristling with rows of tiny vials. Each vial contains a small amount of a different molecular compound the UM chemistry professor and his fledgling company, Promiliad Biopharma, have synthesized and are now screening in hopes they might one day be used to cure some of the world's deadliest diseases.

These, he explains while pulling out a rack, are the libraries.

Since 2002 Priestley and his partners at Promiliad have been hard

Looking for cures: Priestley works in his lab, where he modifies bacteria that may fight cancer, viruses or infection.

at work, tiptoeing through the painstaking process of first genetically modifying existing antibiotic bacteria, arranging the resulting new compounds into libraries and then assaying them to find out which, if any, might be used to fight cancer, viruses or bacterial infections such as methicillin-resistant *Staphylococcus aureus* (MRSA), Vancomycin-resistant *Enterococci* and Cryptosporidium. To date the company has some 3,000 compounds in its libraries. If it is successful in proving that just one of them is effective on any one of a vast number of diseases, it will mean the creation of a whole new class of drugs to aid the management of the most treatment-resistant ailments — medicine, Priestley says, that's badly needed.

"One of the big problems in health care is antibiotic resistance," he says. "If you go into a hospital, you've got a one-in-10 chance of coming out with a bug that you didn't have when you went in there. Bacteria are always going to generate resistance to drugs that are in the clinic, and the real problem is that we've only come up with four new classes of antibiotics in the past 30 years. There are a lot of new drugs, but they're all more cephalosporins or penicillins or 'me too' kind of drugs. Very rarely do you come up with a new class of drugs."

How close are they? Closer than you might think.

Priestley estimates that right now Promiliad could sell its compound libraries to other researchers or another pharmaceutical company for several million dollars. They could, in a sense, get rich quick, cashing in their work up to this point on a small fortune to let somebody else do the tedious work of assaying each compound in each library against a wide catalog of diseases and a seemingly limitless number of possible pitfalls.

"Of course," he says, flashing a grin that's half idealistic academic, half shrewd entrepreneur, "we would never do that."

At his core, Priestley is a chemistry professor's chemistry professor. Spend five minutes talking to the affable, quick-witted Englishman who came to UM from Ohio State University in 1999, and you can tell there are two reasons he and Promiliad won't consider selling their libraries. First, because they're having too much fun messing around with them and, second, because they could be nearing a breakthrough worth far more than what they might fetch for bowing out now.

After nine years of examination and assays, Promiliad has two compounds that are taking baby steps toward the holy grail of biopharmaceutical testing — an "investigational new drug" (or IND) filing and entry into the early phases of human trials. As it stands, one of Promiliad's compounds already shows efficacy in treating MRSA in mice, and the other compound is on the verge of beginning animal testing. In other words, it shouldn't be long now.

"I would trade every one of my scientific publications just for getting one

IND application passed," Priestley says. "Of course, it's a long row to hoe before you get it in the clinic, but animal study is the first really big hurdle, because when it works there you know you've got something that isn't just pie in the sky."

Within about 24 months, the company should know if either of its compounds will pass muster, or if it has to begin all over again with the frustration of testing new compounds against new targets. It's a progression Priestley describes as "like sitting on an old bed." Push down on one spot, a problem pops up somewhere else. Shift the weight of your focus onto that area, the springs on the opposite side might start to creak and groan.

"Think of it as a funneling process," he says. "You start off with thousands of compounds. You get rid of all those that aren't active against the target bacteria. Then you get rid of all those that kill mammalian cells. Then you get rid of all those that won't be soluble. Then you get rid of all those that aren't active in an animal model. Then you get rid of all those that fail in clinical trials. At the end of the day, after maybe eight, nine years, you end up with one compound."

Well, one or two.

If either of Promiliad's compounds land in hospitals, it will amount to an enormous academic and financial windfall for the company's founders and, by extension, for UM.

As it stands, Priestley and his business partners rank in the top 10 in Montana for National Institutes of Health grants, totaling more than $3.5 million worth of research during the past several years. All in all, its current prospects aren't too shabby for a venture Priestley freely admits has been a difficult learning experience for a bunch of scientists trying to forge their way in the private sector and one that began, at least partly, out of frustration that they couldn't even get an NIH grant when they started applying for them back in 2002.

Though in recent years the company has successfully procured grants, Priestley says Promiliad's main focus is advancing to the point where it generates enough revenue to fund its own research moving forward. That'll happen — and then some — if either of its current products pan out, lead to successful IND filings and then get licensed to larger pharmaceutical companies. It could also mean earnings for Priestley and his business partners that go far beyond a mere $10 million to $20 million.

If neither works out? Then the company goes back to the fridge to find a new compound from its libraries. For his part, Priestley isn't holding his breath. He loves his day job anyway.

"Yes, there is the potential for a lot of money to be involved, but you can't rely on that coming in," he says. "We're doing this because it's fun to do ... If they said, 'Here's a million dollars, but you're not allowed to do research anymore,' I wouldn't take it. Fifty million? Maybe."

For more information email nigel.priestley@mso.umt.edu.

A close-up of some of the bacteria Priestley studies

"One of the big problems in health care is antibiotic resistance. If you go into a hospital, you've got a one-in-10 chance of coming out with a bug that you didn't have when you went in there."

A Petri dish with some of the UM professor's work

At the bottom of his faculty biography on UM's website, Charles Dumke lists one of his extracurricular interests as: "Selling the idea that exercise is medicine."

As an exercise physiologist and professor in health and human performance at UM, that mission statement has defined much of Dumke's research into exercise nutrition, fuel utilization and energy expenditure for the past 17 years. Nowhere is it perhaps more applicable than in his ongoing research into Type 1 diabetes.

Dumke came to Montana three years ago from Appalachian State University in North Carolina. He has worked with diabetics for some time now, both consulting with diabetic athletes training for Ironman triathlons and attending exercise camps for Type 1 diabetics all over the country. One such trip to a Chicago camp back in 2008 belatedly earned Dumke some unexpected media attention recently, after the surprising results of a test he conducted netted him the opportunity to present his findings at the annual conference of the American College of Sports Medicine in Denver in June.

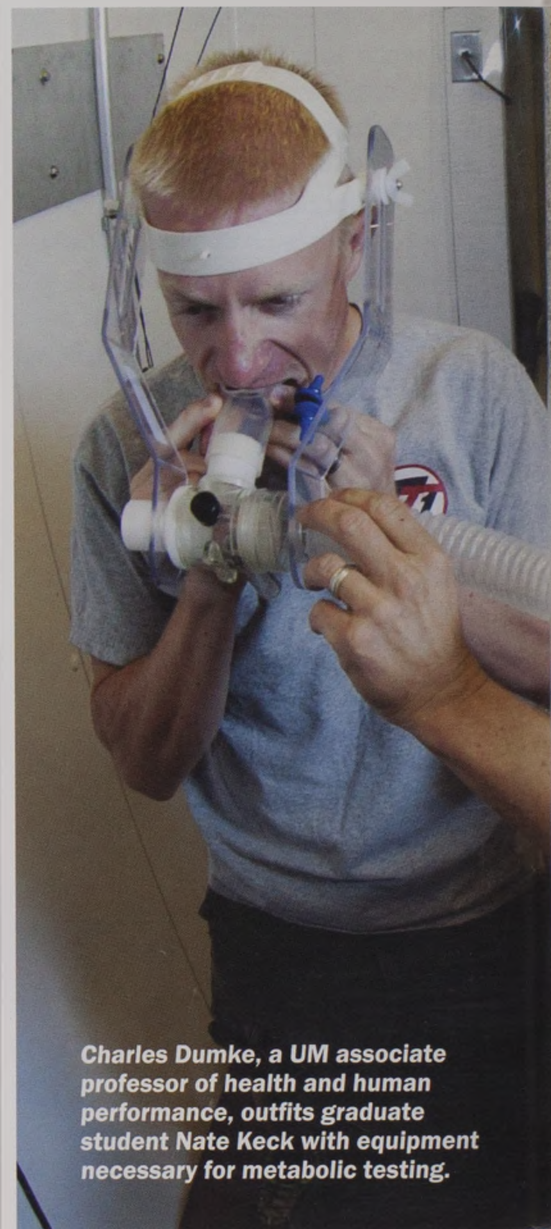
Given what he describes as "an unbelievable paucity of research out there on Type 1 diabetes and exercise," Dumke set out to compare fuel utilization in "Type 1s" (as they're sometimes called) to healthy adults by conducting incremental exercise tests to exhaustion on 29 attendees at the camp. Those results were then cross-referenced against a control group of people who don't have diabetes.

Individuals with Type 1 diabetes suffer from a disease that differs from the more talked-about Type 2 diabetes — which is brought on by lifestyle choices — in that it may be genetic, is autoimmune in nature and is caused by the body's destruction of insulin-producing cells in the pancreas. The lack of insulin leads to an increase of blood glucose and results in Type 1s facing a lifelong regimen of managing their levels through injections and the use of insulin pumps. Maintaining the delicate balance between insulin and glucose can make exercise risky and difficult for Type 1s, so the more we understand about how their bodies react during the physical stress of a daily workout, the better.

"It's a complicated interaction, which is what makes it such an interesting scientific investigation," Dumke says. "Ours was kind of a relatively simple study, but it was a rare opportunity because when do you get 30 Type 1 diabetics of similar age range and fitness all together at once, with the capability to do these measurements?"

Simple study maybe, but when he got around to analyzing the results of the three-year-old study in preparation for last summer's ACSM conference, what he found was a bit unexpected.

"Insulin is a very powerful inhibitor of fat use, so when they have less insulin and they have high blood glucose, what's the fuel left to use? It's fat ..."



Charles Dumke, a UM associate professor of health and human performance, outfits graduate student Nate Keck with equipment necessary for metabolic testing.

Dumke expected to see no difference in the fat and carbohydrate oxidation rates of the Type 1s and the control group, but it turned out that, at least under the specific circumstances of this test, the diabetic group was burning more fat and fewer carbs. Dumke says this likely occurred because participants were asked to fast for two hours before climbing on a stationary bike or treadmill to take the tests. That fast no doubt resulted in lower insulin levels in the Type 1 diabetics, despite their higher blood glucose levels, and, as a result, more fat expenditure.

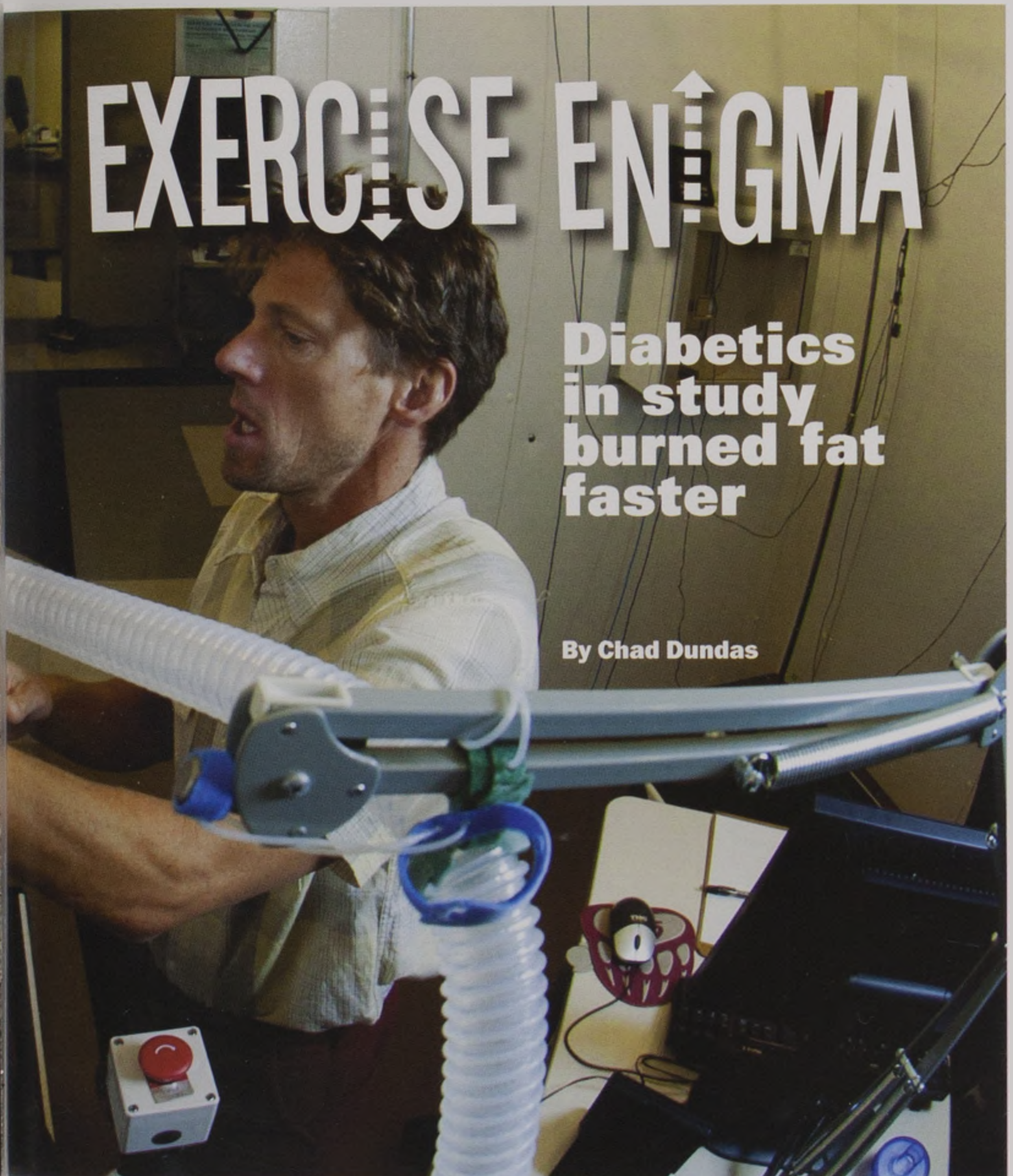
"Insulin is a very powerful inhibitor of fat use, so when they have less insulin and they have high blood glucose, what's the fuel left to use? It's fat," Dumke says. "So the practical application of that is that insulin not only controls how much glucose is taken up into tissues, it's also regulating the type of fuel you are using."

In certain ways, these findings present Dumke with the age-old dilemma of the research scientist. To the layperson, the average newspaper reader or the reporters who knocks on his office door, the eternal questions are: What does it all mean? How will it affect us? How can we use it? While Dumke certainly understands that impulse, he's somewhat loathe to talk about the possible real-world implications of this research. The last thing he wants is for a bunch of people to start trumpeting from the rooftops that diabetics might gain an exercise advantage if they start reducing

EXERCISE ENIGMA

Diabetics in study burned fat faster

By Chad Dundas



their insulin levels.

"I don't want that to happen," Dumke says. "I have to be very cautious because there's a huge individual variability between Type 1 diabetics, and I don't want generalized statements from a research study to become individual consulting. That's a danger, and I don't want that message to go out there."

What's important, Dumke says, is to make sure that Type 1 diabetics and their health care providers – whether it be nutritionists or endocrinologists – use the information to increase their overall understanding of how diabetics can and should safely exercise. Many Type 1s who exercise regularly are probably already lowering their insulin intake beforehand, and Dumke's study just provides them with a more complete picture of what's happening inside their bodies when that happens.

"That is a very common thing," he says. "A lot of Type 1 people, when they exercise, typically have instructions from their endocrinologist to lower their insulin administration because insulin and exercise can be similar in their ability to take up glucose into tissue. So when they exercise with insulin, a Type 1 diabetic is already in jeopardy of causing a hypoglycemic low. Their instructions then are to lower insulin when they exercise in order to lower that risk. That then, we found, predisposes them to using more fat."

Some Type 1 diabetics have come to terms with how to properly exercise, but others are still struggling with it, some too fearful to even try. Very real concerns about hypoglycemic lows and diabetic comas make it even more important that Type 1s get the proper education and instruction on how to exercise the right way, Dumke says.

"When I showed up at these camps, I was all excited about getting them (Type 1 diabetics) some exercise, and here they are, afraid to do any exercise," he says. "By giving them more of a well-rounded background in exercise physiology, they felt much more comfortable in being able to understand this [insulin-glucose] interaction. That was a really profound realization for me because I'm usually in the lab doing research and don't always have that one-on-one consulting experience."

In other words, it was a matter of selling the diabetics on the idea that exercise is medicine. No worries for Dumke though, who at 45 years old himself looks fit as a fiddle from a regular regimen of biking, running, swimming and triathlons. That, coupled with his knowledge, makes him a pretty good salesman. V

For more information email charles.dumke@mso.umt.edu.

Dumke works to sell the idea that "exercise is medicine."

MECHANICS OF MOVEMENT

RESEARCHER STUDIES LIMITS OF 'THE HUMAN MACHINE'

vement

By Jennifer Savage

Bundle (left), who captained the Harvard cross country and track and field teams, first became interested in human movement while trying to become a faster runner.

Matt Bundle, a scientist who studies the biomechanics of human movement, recently moved his research operation to UM. He is shown here in the University's Montana Center for Work Physiology and Exercise Metabolism.

Matthew Bundle studies the science of how people move.

He researches the upper limits of human speed and how brains control our muscles. He studies the rates of human metabolism and why our muscles use the energy they do. He examines men, women, the fast and the slow, people with biological limbs and those without. He studies the tiny nuances of gait, the effect of calories and age on performance and how the skeleton, muscles and supporting organ systems conspire to limit the human machine.

"Biomechanics is about the function of our anatomy, the relationship between the structures in our bodies and how they work," Bundle says. "I study how the physical laws of mechanics have influenced our biology and apply this understanding to things such as injuries or the movements we perform in everyday life."

Bundle made international headlines in 2009 when he and colleague Peter Weyand split from the rest of a team that conducted scientific testing on Oscar Pistorius, a South African double-amputee sprinter, who was appealing his ban from Olympic competition. Bundle noted that even though they admired and were inspired by Pistorius' performances using his artificial legs, the scientific evidence clearly indicated that his "lightweight, compliant" limbs gave him considerable advantage over runners with biological limbs.

"The question there was: Do lightweight, spring-like, carbon-fiber prosthesis work differently than biological limbs?" Bundle says. "With a few straightforward tests that we developed over the past dozen years, we evaluated the biomechanics of how these limbs move and compared that to people with intact limbs. Surprisingly, the carbon-fiber prosthesis had a substantial advantage."

The Pistorius controversy may be heating up again as the man known as the "Blade Runner" makes a bid for the 2012 South African Olympic team. While Bundle is anxious to pursue many of the exciting scientific issues that are related to this project, he says, "The data comparing Mr. Pistorius' prostheses to intact limbs is clear, and the question of whether they provide an advantage over biological limbs has been asked and answered."

Luckily, Bundle has many other research interests.

Bundle is trim, fresh-faced, clear-eyed and excited about the practical application of the science of biomechanics. The only thing he may be more excited about is that this past summer he moved his studies to UM's Phyllis J. Washington College of Education and Human Sciences. As a new assistant professor in the Department of Health and Human Performance, no one is happier than Bundle that he and his team of two graduate students have come to Missoula to continue the work they started at the University of Wyoming, where he directed that university's biomechanics laboratory.

"I'm thrilled to be here," he says

Bundle studied the mechanics of bird flight as a UM doctoral student. Here he releases a chukar while studying wing-assisted incline running in UM's Flight Laboratory.

recently on the UM campus. "Everyone has been so welcoming."

Bundle was comfortable and enthusiastic the day he was interviewed. He is, after all, returning to UM, an institution he loves and one where he earned his doctorate in 2005. At the same time he's returning to Missoula, a town he says he, his wife and their daughter are proud to call home.

"I received great training at this university, and I am anxious to provide my students with the same kind of education and mentorship that I received here," Bundle says. "I want my students to contribute to the long line of excellent researchers that have begun their careers at UM."

In addition to teaching this fall, Bundle and his students will analyze recently collected data about head injuries in sporting events and prepare for the next wave of experiments, including one study focused on combat amputees in cooperation with staff at Walter Reed National Military Medical Center.

The practical application of his findings interest Bundle. And these two studies represent what he calls "good application," where his experimental observations and data can result in useful outcomes for members of the public.

"We typically have both a basic science and an applied interest in the experiments we pursue," he says. "Through these tests we can affect public health outcomes. For example, our work with human speed can inform how a prosthesis should be designed in order to get people up to speed after an amputation. We also can evaluate the changes in balance that occur during sports injuries and possibly come up with an effective, on-site and immediate way to identify people who are at risk of serious impairment if they return to play."

Experiments and the data analysis that go along with them will keep Bundle and his team busy as they settle in at UM, but possibly their most important task this fall is to turn a concrete shell of a basement into a high-tech laboratory, a place where all of their studies will culminate.

Standing in the basement of UM's education college building in flip-flops the week before school started, Bundle was animated when he talked about the new biomechanics laboratory he feels fortunate to be creating. He talked of a specialized treadmill that can measure stride-to-stride variations and clinical deficiencies. He talked of a high-speed camera that slows down motion and documents micro-movements, allowing him to study the dynamic function of the leg. He points to the middle of the room where he plans to dig a hole in the concrete floor to accommodate a highly sensitive force plate that will measure how forcefully a person's foot strikes the ground.

"We'll have offices over here," he points to a corner where several dozen old paint cans currently reside. "If you look down this hallway, there's nearly 50 meters, so we'll be able to use that space as a runway for our gait-related studies."

Bundle says that the latest technology and equipment allows him to spend time developing algorithms and sophisticated measuring systems. And some of that equipment is not commercially available. As a result his team will likely build, modify and instrument some of the tools they need for the lab as well.

"In our line of work, the experiments dictate our equipment needs," he says.

If you take a step back and look at Bundle in what will be his laboratory, you can see the collegiate track and field athlete he used to be and understand just a little more how he came to love the science he's now known for.

As an undergraduate at Harvard University, Bundle became interested in how the body works because he wanted to become a better runner. He began studying comparative anatomy and physiology and also captained both the cross country and track and field teams at Harvard. He took a class taught by renowned physiologist C.R. Taylor, who studied the movement of animals all over the world. Bundle eventually worked in Taylor's lab, admiring his discoveries and the applications of his work.

It was at Harvard's Concord Field Station that he met UM biology Professor Ken Dial and decided to pursue graduate work in UM's Flight Lab, studying muscle function in bird flight. As a Montana graduate student, he continued his study of human performance. After UM he accepted a post-doctoral position at Rice University and then made his way back West to Laramie, Wyo., and the university there.

Now back at UM, it's time for the next chapter in his ongoing trek to unlock the secrets of human movement.

For more information email matt.bundle@mso.umt.edu.

Bundle likes research that represents what he calls "good application," resulting in useful outcomes for members of the public.

Be humble for you are made of earth.
Be noble for you are made of stars.

— Serbian proverb

A star nursery that is part of the Carina Nebula, 7,500 light years from Earth (Credit: NASA, EAS, M. Livio and Hubble 20th Anniversary Team)

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Messier 82 starburst galaxy
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